# 7900 Ventilator

Supplemental to the Datex-Ohmeda Excel SE
and Modulus SE Anesthesia Machine Service Manual.
Ventilator Software Revision 2.X

# Ohmeda 7900 Anesthesia Ventilator

## Supplement to Excel SE and Modulus SE Anesthesia Machine Service Manual

## Ventilator Software Revision 2.X

1503-0151-000 3/27/97

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# Notes

# 1/Introduction

## Important

The information contained in this service manual pertains only to those models of products which are marketed by Ohmeda as of the effective date of this manual or the latest revision thereof. This service manual was prepared for exclusive use by Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Ohmeda provides this service manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities can be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from Ohmeda does not imply in anyway that Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, can not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Technical Publications, Ohmeda, Ohmeda Drive, Madison, Wisconsin 53707.

**CAUTION:** ⚠ **Servicing of this product in accordance with this service manual should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.**

## Technical Competence

The procedures described in this service manual should be performed by trained and authorized personnel only. Maintenance should be undertaken only by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

Ohmeda strongly recommends using only genuine replacement parts made or sold by Ohmeda for all repair parts replacements.

## Special Notice

- Some information in this manual can possibly point the reader to electronic troubleshooting and component/repair replacement level of service. This information, when supplied, is only supplied to add clarity to service or trouble shooting statements. Ohmeda Service

Personnel are mandated by Company Policy to service electronic equipment to a board replacement level only.

- Read completely through each step in every procedure before starting the procedure; any exceptions can result in a failure to properly and safely complete the attempted procedure.
- Unless otherwise specified, values in this manual are nominal.
- Sections in this manual begin on odd numbered or right-hand pages. If there is no text on the preceding, backup even numbered page, it is labeled "NOTES:" for your use if you wish.
- Figures that require more than one page have the title and main text on the left (even numbered) page; Additional figure information is on the facing (odd numbered) page.

## Some terms used in this manual

**Note:** A Note provides additional information to clarify a statement in text.

Important: An Important statement is similar to a note, but provides a comment of greater emphasis.

**WARNING:** ⚠ **A Warning statement, with this symbol, warns the reader of the possibility of injury to the patient or operator/service person.**

**CAUTION:** ⚠ **A Caution statement with this symbol, cautions the reader of the possibility of damage to the equipment.**

## 1.1. What this manual includes

This manual covers the Ohmeda 7900 Anesthesia Ventilator which is an integral component in the Ohmeda Excel SE and Ohmeda Modulus® SE Anesthesia Systems.

Data on the control module troubleshooting, disassembly, repair, reassembly, testing and calibration are included.

The Excel SE and Modulus® SE Anesthesia Gas Machines each have their own service manuals.

## 1.2. Symbols

The following common symbols are used in Ohmeda manuals and on products, however, no one product nor manual has every symbol listed. Refer to this list concerning various symbols found.

| | | | |
|---|---|---|---|
|  | **On (power)** | | **Movement in one direction** |
| | **OFF (power)** | | **Movement in two directions** |
| | **Stand-by** | | **Lock** |
| | **Stand-by or preparatory state for a part of the equipment** | | **Unlock** |
| | **ON only for part of the equipment** | 134°C | **Autoclavable** |
| | **“OFF” only for part of the equipment** | | **non-autoclavable** |
| | **Direct Current** | | **Type B equipment** |
| | **Alternating Current** | | **Type BF equipment** |
| | **Protective earth ground** | | **Type CF equipment** |
| | **Earth ground** | | **Warning or Caution, ISO 7000-0434** |
| | **Frame or chassis ground** | | **Attention, consult accompanying documents, IEC 601-1** |
| | **Alarm silence button** | | **Dangerous voltage** |
| | **Equipotential** | | **Input** |
| | **Variability** | | **Output** |
| | **Variability in steps** | REF. | **Stock Number** |
| | **This way up** | SN | **Serial Number** |

# 1/ Introduction

| | | | |
|---|---|---|---|
| + | **Plus, positive polarity** | CE XXXX | **Systems with this mark agree with European Council Directive (93/42/EEC) for medical devices when they are used as specified in their Operation and Maintenance Manuals. The xxxx is the certification number of the Notified Body used by Ohmeda's Quality Systems** |
| − | **Minus, negative polarity** | | **Read top of float** |
| | **Lamp, lighting, illumination** | | |

# 1.3. Standard Service Procedures

## Operation and Service Manuals

You must have, and be familiar with, the Operation and Maintenance manuals for this product. Study the Anesthesia Systems Operation and Maintenance manuals if you need further information about the operation of the system. You must determine where a problem is located before you can determine which service manual to use. Refer to the various service manuals or accessory manuals if you require more information.

Service calibration functions allow Ohmeda trained users and Ohmeda service personnel to perform ventilator setup functions, tests, calibration and measurements from the front panel display or from commands sent to the proprietary serial port.

## Ventilator Tests

Normal operational tests can be performed while the Ventilator is installed in, or attached to, an Anesthesia System. Calibration, troubleshooting or repair may require removing the Ventilator from the Anesthesia Machine.

---

**WARNING:** ⚠ **Section "4/Test and Troubleshooting" must be performed whenever you remove a Ventilator cover, to verify that all critical parts of the Ventilator are still operational and within specification.**

**WARNING:** ⚠ **After the Ventilator has been serviced, you must perform "Post-Service Checkout" to verify the entire Anesthesia System is properly functioning before the system can be returned to clinical use.**

**WARNING:** ⚠ **Do not perform testing or maintenance on this instrument while it is being used to ventilate a patient, possible injury may result.**

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# 1.4. 7900 Ventilator Configuration

The 7900 Ventilator; (hereafter called Ventilator) is an integral part of the Modulus SE and the Excel SE Anesthesia Systems. This Ventilator is not available for use as a stand alone piece of equipment.

## The Ventilator is composed of two basic units:

- the breathing circuit interface: ABA (Autoclavable Bellows Assembly); Bellows and Bellows Housing,
- the Control Module; containing the control valves, processing circuits, controls, monitors and display screen.

## Software Versions

This manual includes test and calibration procedures for Revision 2.X software. As software is revised and updated, the revision level is displayed on the ventilator start-up menu.

## Notes:

# ZZZ2.1. General

The 7900 Ventilator is a microprocessor based, electronically controlled, pneumatically driven ventilator with a built in monitoring system for inspired oxygen, airway pressure and exhaled volume. The 7900 is a "Closed Loop Control Ventilator." Sensors in the breathing circuit are used to control and monitor patient ventilation as well as measure inspired oxygen concentration. This allows for compensation of compression losses, fresh gas contribution, valve and regulator drift and any small leakage in the breathing absorber, bellows and system. User settings and microprocessor calculations control breathing patterns. The 7900 has a user-selectable Heliox mode to allow gas composition compensation when Heliox gas is used.

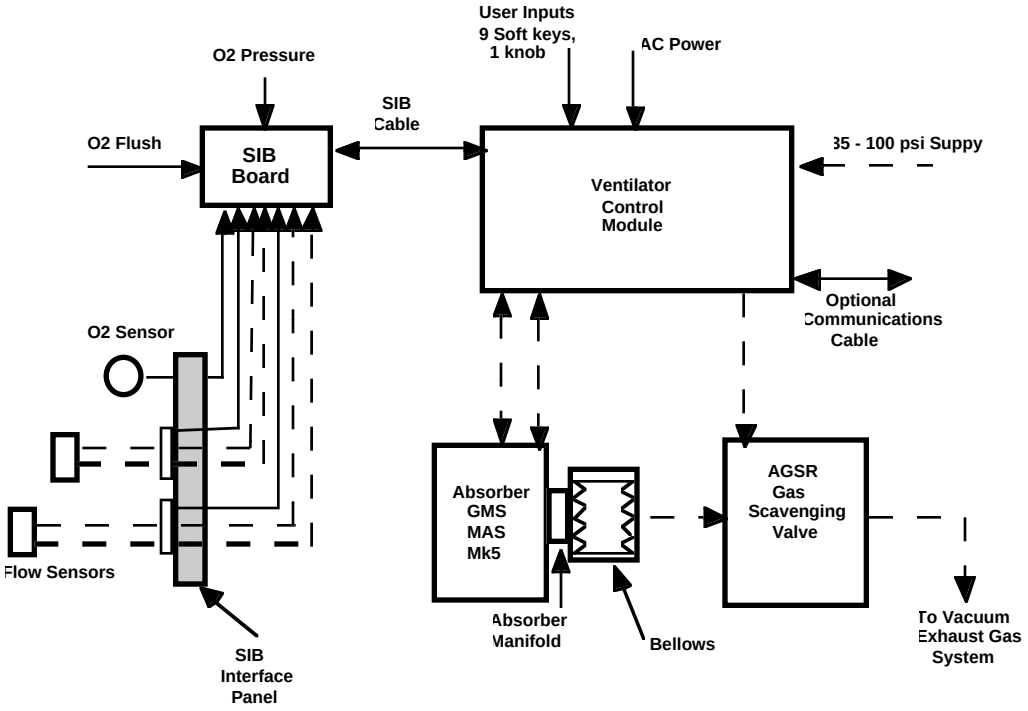



**Figure 2-1**
7900 Ventilator - Excel SE and Modulus SE Anesthesia System Interface.

User interface settings are stored in non-volatile memory. The user may change settings with a simple and secure setting sequence. A bellows contains breathing gasses to be delivered to the patient

Positive End Expiratory Pressure (PEEP) is regulated electronically. Positive pressure is maintained in the breathing system so that any leakage occuring is compensated for by the ventilator to maintain PEEP.

An RS-232 serial digital communications port connects to and communicates with external devices.

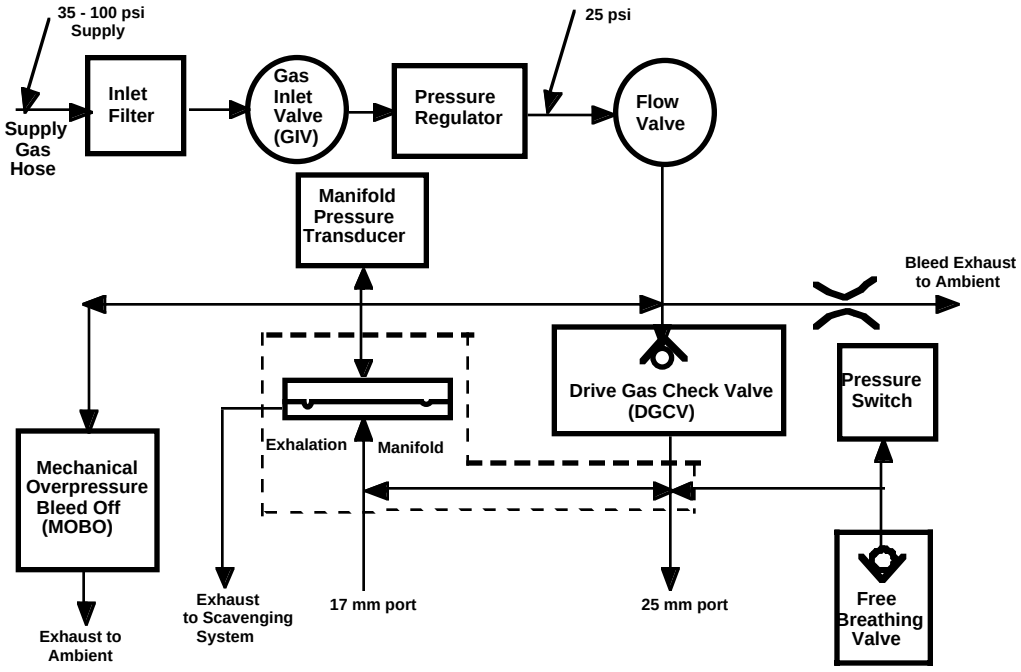



**Figure 2-2**
7900 Ventilator Operational Block Diagram

## Some 7900 Ventilator Features

- No secondary regulator or exhalation solenoids
- An exhalation valve that modulates flow in the pressure mode rather than being just on and off
- Pressure and volume mode selectable by the operator
- All pneumatic components are mounted on a single manifold.
- Each component is individually accessible from above or below the manifold
- There are no threaded connections to the subassemblies
- Drive gas and bellows pressure relief valve gases are combined and pass through the ventilator exhalation valve.
- Exhalation valve block is autoclavable
- Scavenging line runs from the ventilator to the Anesthesia Gas Scavenging Receiver (AGSR) which scavenges both drive gas and gas released by the bellows pressure relief valve.
- Operates in a "Closed-Loop" configuration during both volume and pressure modes of operation
- Easier to service, fewer components and improved performance.

## Safety Features

- Dual redundant airway over pressure protection, linked to the Pmax setting
- Volume over-delivery limits and protection
- Ohmeda proprietary hose connections - fixed manifolds to reduce leaks
- Uses proven mechanical components
- 10 VA - Oxygen compartment separation
- 500 psi burst protection

# 2.2 Mechanical

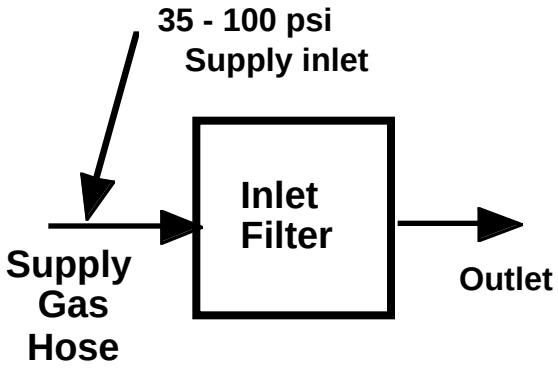



**Figure 2-3**
Supply gas inlet, filtered

**Supply Gas** which can be powered from O2 or Air, is supplied from the anesthesia machine at a pressure of 241 to 690 kPa (35 to 100 psi). This supply gas is filtered through the 5 micron filter and water trap to further eliminate any minute particles of contaminate. The filter does not significantly reduce the output pressure on the downstream side of the filter.

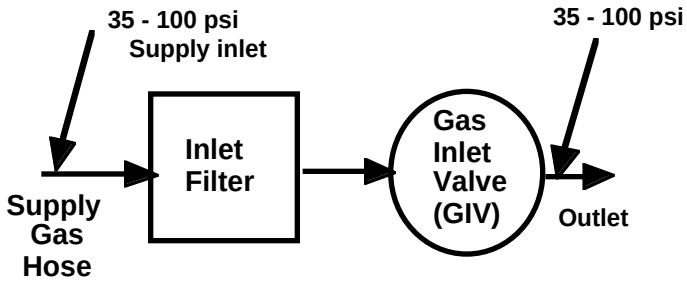



**Figure 2-4**
Gas Inlet Valve

During normal operation the **GIV (Gas Inlet Valve)** is open to allow the supply gas to flow to the ventilator manifold. This valve provides a shut off of the supply gas to the ventilator when the ventilator is not in use. The GIV also shuts off supply gas to the ventilator under failure conditions as the microprocessor or over-pressure switch demands. The output from the GIV remains at the filtered supply gas pressure.

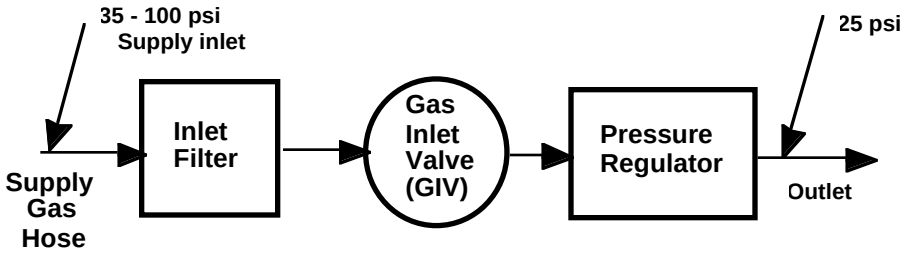



**Figure 2-5**
Non-Relieving Pressure Regulator

The pressure regulator is a **Non-relieving Pressure Regulator** which regulates the high pressure filtered supply gas, oxygen or medical air, down to 172 kPa (25 psi).

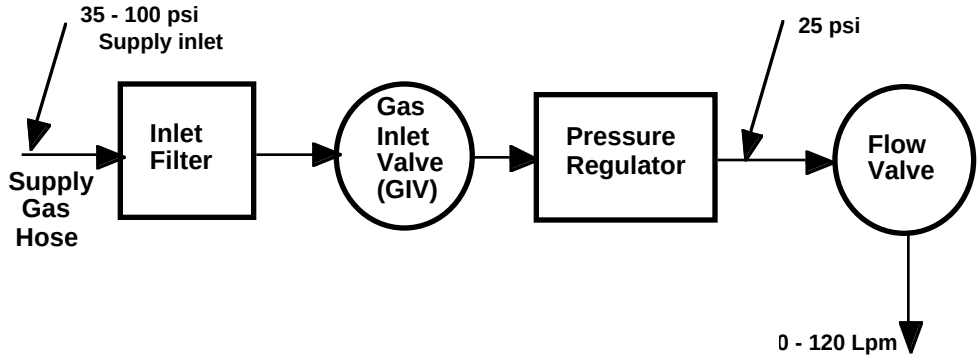



**Figure 2-6**
Flow Control Valve

The Flow Control Valve is controlled by the microcontroller. Signals are sent to the Flow Control valve which correspond to the generated flow requirements called for by ventilator settings and sensor signals. The Flow Control Valve modulates the incoming 25 psi drive gases to a variable output from 0 to 120 liters per minute at pressures nominally ranging from minus 10 to plus 100 $cmH_2O$.

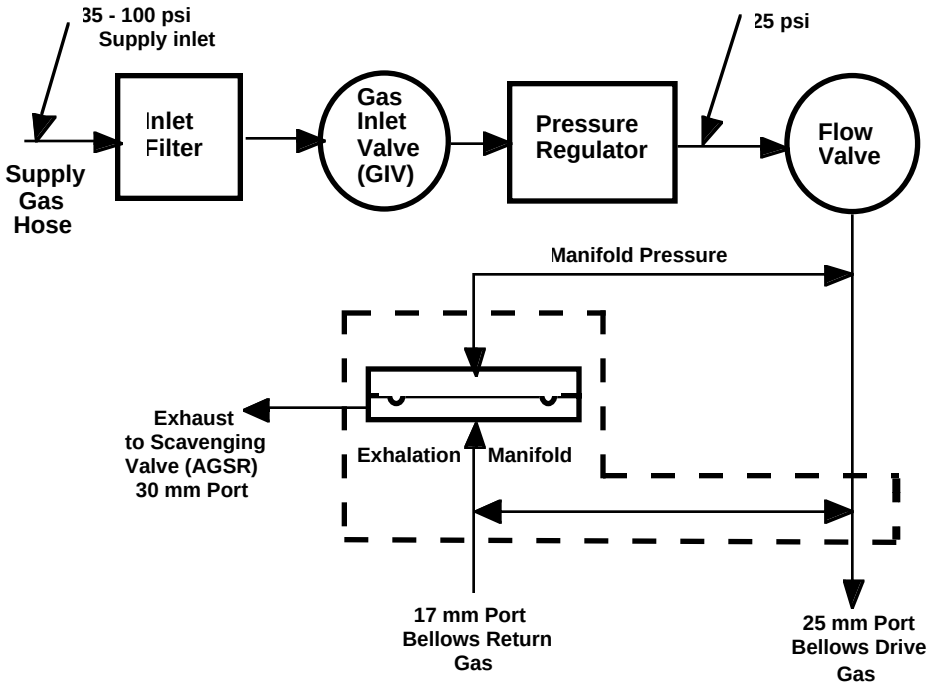



**Figure 2-7**
Exhalation Manifold

The autoclavable **Exhalation Valve Manifold** contains an elastomeric diaphragm used in association with the flow valve to control the pressures within the breathing circuit. The manifold contains ports for the bellows drive gas (25 mm), the bellows return gas (17 mm) and the AGSS (Anesthesia Gas Scavenging System) (30 mm). Pilot control of the exhalation valve is accomplished through pneumatic connections internal to the 7900 ventilator main pneumatic manifold. The valve is normally open, requiring approximately 2 $cmH_2O$ of pilot pressure to seal the breathing circuit.

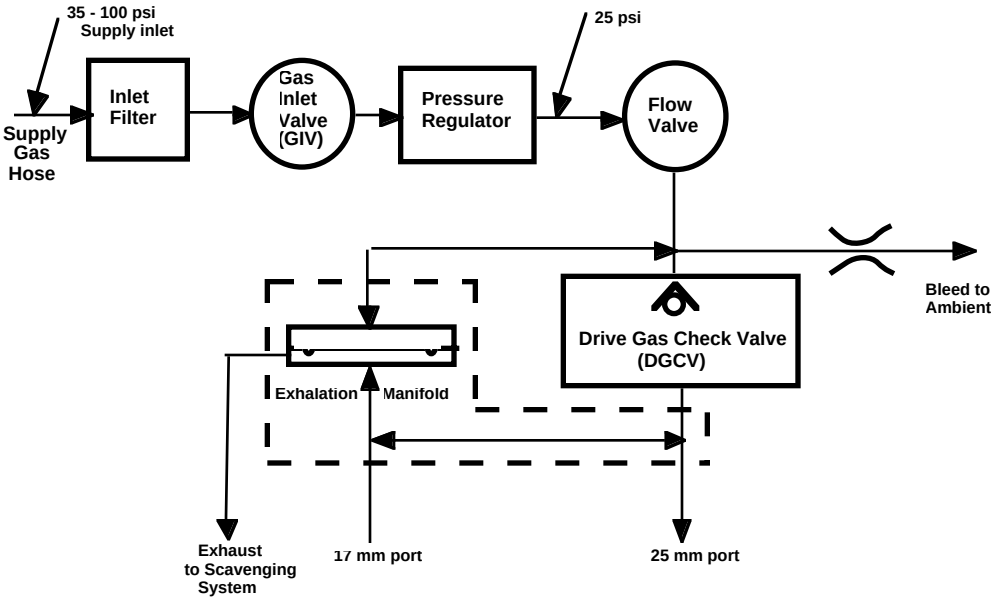



**Figure 2-8**
Drive Gas Check Valve

In order to generate the required pilot pressure for sealing the exhalation valve during inspiratory periods, a **DGCV (Drive Gas Check Valve)** is used downstream of the exhalation valve pilot connection. This valve is biased shut using an integral weight so as to generate approximately 3.5 $cmH_2O$ of bias pressure prior to allowing flow downstream to the breathing circuit. During periods of operation when the ventilator is exhausting flow from the breathing circuit, the DGCV allows the exhalation valve pilot pressure to be de-coupled from the circuit pressure, thus allowing the exhalation valve to open and flow to exhaust and the scavenging system.

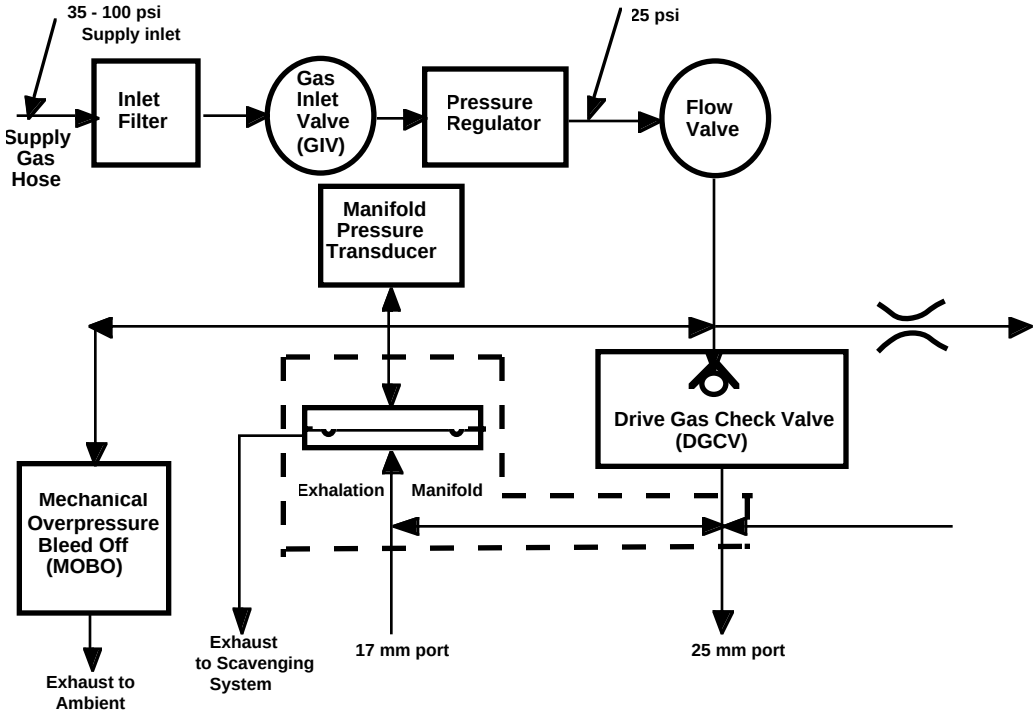



**Figure 2-9**
MOBO (Mechanical Over pressure Bleed Off)

**The Mechanical Over pressure Bleed Off Valve** is a mechanical valve operating even if there is no electrical power. The MOBO has two functions. First, it serves as a third level of redundancy to the ventilator's pressure limit control functions, providing pressure relief at approximately 110 $cmH_2O$. Second, the MOBO serves as a backup in the event of a complete blockage of the exhalation valve system, relieving circuit pressure at approximately 30 $cmH_2O$ under such failure conditions.

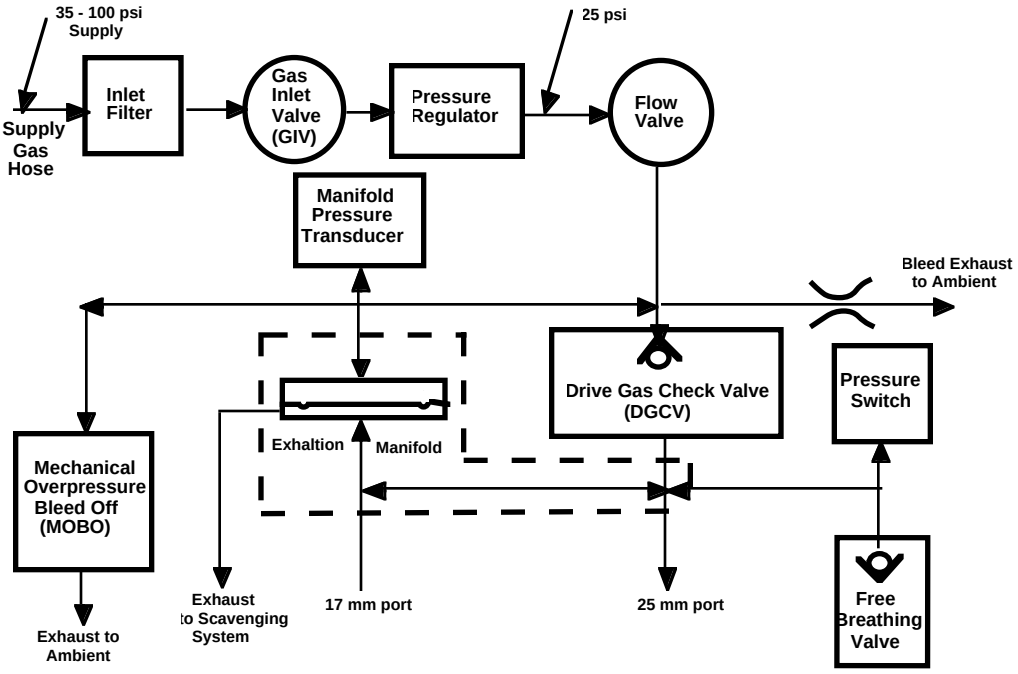



**Figure 2-10**
Bleed Resistor, Pressure Switch and Free Breathing Valve

**The Bleed Resistor** is, by design, a "controlled leak" from 0 to 10 L/min. in response to circuit pressures from 0 to 100 $cmH_2O$. The small amount of pneumatic flow exhausting through the bleed resistor allows for control of the exhalation valve's pilot pressure by modulation of the valve output. The bleed resistor exhausts only clean drive gas and should not be connected to a waste gas scavenging circuit. The output is directed away from the electrical components to ensure that systems using oxygen drive gas meet the 10VA requirement for oxygen enrichment.

**The Pressure Switch** is an electrical limit which automatically shuts off the GIV (Gas Inlet Valve) and flow valve if the pressure reaches a level of approximately 104 $cmH_2O$. When either or both of these valves is shut, the pilot pressure to the exhalation valve falls rapidly as the flow discharges out the bleed resistor. As the pilot pressure is relieved, the exhalation valve opens allowing circuit pressure to be relieved.

**The Free Breathing Valve**, also shown in figure 2-10, allows the patient to take a spontaneous breath. The ventilator is programmed to supply a certain number of breaths per minute to the patient. If, in between one of these programmed cycles, the patient requires a breath (spontaneous) the free breathing valve allows the patient to inhale ambient air spontaneously.

## 2.3. Electrical

The 7900 Ventilator consists of the following electronic/electrical subassemblies or modules:

- Microcontroller Printed Circuit Board
- Front Panel Assembly
- Power Supply and External I/O Interface Board
- Sealed Lead Acid Battery
- Power Entry Module and Toroid
- Sensor interface board

The specific function of each of these items is described in subsequent sections.

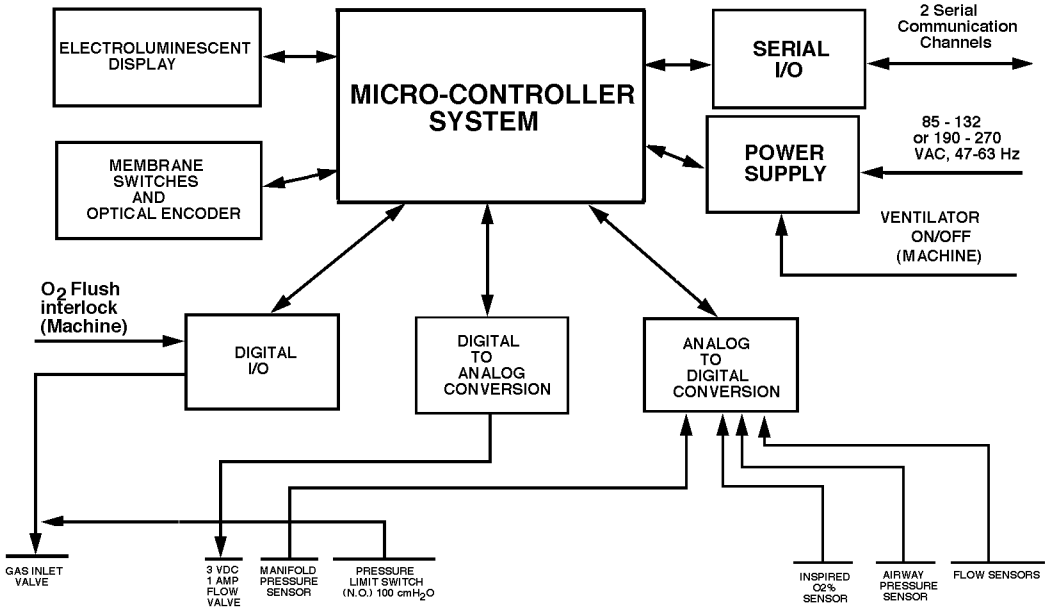



**Figure 2-11**
Electronic functional block diagram

## Power Supply Assembly

The power supply board encompasses two functional blocks: power supply and external interface.

### Power Supply

The power supply is divided into three stages,

- ac to dc Conversion
- dc Step-down Regulator and Battery Charger
- Multiple Output dc to dc Converter

#### Functional Specifications

- Autoranging input 85-132 and 190-270 Vac, 47-63 Hz, 54.5 VA.
- Output 5V for digital circuit, 5.5V for electromechanical actuators, 14.5 V for EL display and ±15V for analog circuits.
- Approval to UL-544, CSA, VDE, IEC-601 and other applicable medical product standards.
- Leakage current under 300 micro Amps @ 132 Vac, 60 Hz.
- Output short-circuit, over-voltage protection, with automatic recovery after removal of fault.
- Battery under-voltage disconnect function protects charging bad cell.
- Battery under-voltage cutoff function protects over-discharging.
- 30 minute battery backup operation under normal application.

#### Power Requirements

- Maximum input requirement: 54.5 VA ac
- Maximum output capacity: 26.7 W dc

#### Heat generation

The maximum heat generated from the power supply is 27.8 Watts.

#### ac to dc Conversion

Input Voltage ranges from 85 to 132 and 190 Vac to 270 Vac, 47 to 63 Hz enters the unit via power entry module with a medical grade line filter. This filtered output is converted to dc voltage via a toroidal isolation transformer and bridge rectifier.

### Power Entry Module

| | |
|---|---|
| • Type | Line Filter with ac Connector & 5 X 20 mm Fuse holder |
| • Maximum leakage current | < 5 μA @ 250V/50Hz |
| • Fuses | 2A 250V. Slow blowing 5X20 mm |
| • Approvals | UL 1283, CSA C22.2/8, VDE 0565 & EN 60320 |

### Toroid

| | |
|---|---|
| • Type | High efficiency toroid |
| • Power capacity | 54.5 VA |
| • Voltage rating | 85-270Vac / 14-45 Vac |
| • Leakage current | 25μA Max. |
| • Power efficiency | 85% - 90% @ 115Vac 60Hz, 60VA |
| • Safety screen thickness | 0.005" Cu. |
| • Isolation hipot voltage | 4KV. |
| • Thermal fuse | Thermik S01 110$^{o}$C |
| • Dimension | 115 mm diameter x 58 mm thickness |
| • Weight | 4.8 lb |
| • Mounting method | Epoxy center hole 0.5 in. ID. |

### ac to dc rectifier

| | |
|---|---|
| • Topology | Full wave bridge/voltage doubling with auto/voltage adapter |
| • Rectifier type | GBU8D 8A, 200V |
| • Peak current surge | 300A (JEDEC Method). |
| • Power efficiency | 92% - 95% |
| • Output filter capacitor | 2 x 5600uF 63WVdc, 3.93A allowable ripple current at 120 Hz, 85$^{o}$C, 2000 hr. load life at 85$^{o}$C 50V 3.93A 120 Hz rip |
| • Output ripple voltage | < 2.5 Vp-p |
| • dc output voltage range | 24 - 62 Vdc |
| • Auto-voltage adapting threshold | 140/155 Vac |

### ac Power-On Indicator

| | |
|---|---|
| • Type | LED |
| • Color | Green |
| • LED drive current | 15mA. |
| • Location | Display Board |

### ac Step-Down Regulator and Battery Charger

The dc step-down regulator takes the output from ac/dc conversion stage (24-62 Vdc) and converts it to 16.6 Vdc. The battery charge circuit charges the sealed lead acid battery anytime ac power is supplied.

A Schottky Diode provides uninterrupted-power-supply (UPS) function during ac-powered to battery powered transitions. When ac power is interrupted, the switch-over between ac and Battery is automatic. When ac power is off, this diode also works as a reverse blocking device preventing the battery from being drained by the regulator circuitry.

## Synchronous step-down regulator

| | |
|---|---|
| • Power efficiency | 80 - 85% |
| • Input voltage range | 24 - 62 Vdc |
| • Switching Controller | MAX797 |
| • Switch devices | 100V 19-28A, 0.20 / 0.07 ohm. MOS-FETMTW 4510E / IRF540. |
| • Output Ripple | Less than 200mV peak to peak |
| • dc output voltage | 16.6 V |

### Lead acid battery charge controller

The battery charge circuit charges the sealed lead acid battery anytime ac power is supplied. This circuit is based on the Unitrode UC3906 charger controller which monitors and controls both the charging voltage and current through three separate charge states:

- a high current bulk-charge state,
- a controlled over-charge,

and

- a precision float-charge.

This sequence maximizes battery capacity and life while minimizing charge time. Switch over circuitry detects the presence or loss of ac supplied power and provide an automatic and transparent transition to AC or battery power.

The charge time for the sealed acid battery, from a discharged state to full capacity is 10 hours maximum.

| | |
|---|---|
| • Charge levels | Bulk charge, over charge and temperature compensated floating charge |
| • Bulk charge current | 250mA (c/10). |
| • Over charge voltage | 14.7V at 25$^{o}$C |
| • Floating charge voltage | 13.7V at 25$^{o}$C. |
| • Auto Charger Disconnect | 7.56 to 8.08Vdc. |
| • Auto Charger Disconnect Release | 7.71 to 8.71Vdc. |

### ac to Battery Automatic Switch Circuit

| | |
|---|---|
| • Battery connection | Direct on dc bus. |
| • Battery standby current | < 200 uA. |

### Multiple Outputs dc to dc Converter

A single dc bus voltage, either from the ac to dc converter or the battery, is the input to a dc to dc converter (MAX 796) similar to that used in the ac/dc section. The converter has the five outputs required by the system at appropriate power levels.

Post low-drop regulators provide the most effective local regulation and high efficiency with over current limiting and thermal shutdown protection. The 15V and 5RS_VAUX outputs are 10VA limited and go through 10VA limit circuitry before being sent to the SIB board and the pneumatic isolation area.

### Voltage Rails Specifications

### Outputs

| | |
|---|---|
| • Digital logic | 5 Vdc +3.685% to -3.05% 5W Max. |
| • +15V | 15 Vdc +15.75 Vdc to + 14.25 Vdc 2W Max. |
| • -15V | -15 Vdc -15.75 Vdc to -14.25 Vdc 2W Max. |
| • EL Display | 10 to 15 Vdc 10W Max. |
| • VAUX | 5.8 Vdc 6.09 Vdc to 4.99 Vdc 7.7W Max. |

### Ripples

| | |
|---|---|
| • 5 VCC | < 50 mVp-p |
| • 5.5 Vdc | < 100 mVp-p |
| • 12 Vdc | < 200 mVp-p |
| • ±15V | < 100 mVp-p |

## External Interface

The external interface of the ventilator is an important design task from the standpoint of Electromagnetic compatibility (EMC). It is important to protect the ventilator from conducted and radiated Electromagnetic Interference (EMI) and from Electrostatic Discharge (ESD). In addition, EMI design precautions are taken to control the emission of EMI via cabling and access ports.

## Communication Interface (RS232C)

There are two RS232C interfaces. Both operate with a maximum baud rate of 38.4K baud. The isolated interfaces eliminate the possibility of ground loops.

## External Interface Connector

This section of the design covers the various inputs and outputs that pass though this connector. Each input or output is protected from EMI and ESD in an appropriate manner.

## Sealed Lead Acid Battery

A sealed lead acid battery provides battery backup operation for the 7900 ventilator. Batteries meet the following requirements:

1. Capacity to operate unit for 30 minutes.
2. Good reliability history with Ohmeda.
3. Long float charge life.
4. Battery pack is internally fused - in line replaceable.

The 7900 is not a portable unit. Batteries for the 7900 Ventilator are used as back up power in case of a power failure. Therefore the battery is in a float charge state most of the time.

Battery terminals and connecting wires are protected against short circuits.

## Input

Nominally 13.7 Vdc at 25$^{o}$C during float charge.

## Output

+10 to +14.8 V dc during discharge

## Microcontroller Assembly

The Microcontroller Assembly contains all of the major circuit functions necessary to control ventilator operation. This assembly consists of the following individual circuits:

Motorola 68340 Processor Core

The CPU core consists of the following internal functions:

- Bus access control signals for all memory and peripheral devices
- Interrupt handling
- Clocks and timers for the system
- Background debug mode
- Two RS232C serial I/O ports
- Baud rate generator for serial ports
- Hard (power-up) and soft (watchdog error) reset generation
- Data bus buffers

Memory and I/O decoding

Program Memory

Safety Relevant Computing

Watchdog System

Data Acquisition

Flow Valve Control

Inlet Valve Drive

Front Panel Interface

Audio Alarm

Regulator Output/Manifold Pressures

### Functional Specifications

#### Motorola 68340 Processor Core

#### System Integration Module

#### System Clock

An external 32.768 KHz crystal is used with the internal clock synthesizer to generate a 24.11 MHz system clock.

#### Periodic Interrupt Timer

The periodic interrupt timer is the time base for the Real Time Operating System.

### Software Watchdog Timer

The software controlled internal watchdog timer guards against program execution going astray.

### External Bus Interface

The external bus interface handles the transfer of information between the CPU32, external memory and peripherals.

### Chip Selects

The four programmable chip selects access external memory and peripheral circuits, providing handshaking and timing signals as well as a wait state generation.

### I/O Lines

Spare I/O lines are used for digital control and/or sense lines.

### Timer Modules

### Counter/Timer #1

The first counter/timer module is used to monitor the 68340 system clock frequency. The external 3.6864 MHz baud rate clock is the time base for this measurement.

### Counter/Timer #2

The second counter/timer module can be used as desired by the application software. The time base for this timer is the internal 24.11 MHz system clock.

### Serial Communications Module

### Timing Reference

An external 3.6864 MHz clock oscillator serves as the basic timing reference for the Baud Rate Generator.

### Configuration

Both of the serial communication channels are configured as full-duplex asynchronous RS232C ports. The internal Baud Rate Generator establishes the communication baud rate, with an upper limit of 38.4k Baud.

### Special Operating Modes

The serial channels are capable of operating in various looping modes for self testing as well as for remote testing of serial communications. These tests include automatic echo, local loop-back, and remote loop-back.

## Program Memory

### Flash EPROM

Two 128K x 8 Flash memory devices are used, with on-board expansion capability to 512K x 8 devices. This memory contains the real time operating system (RTOS) and software code. The Flash memory devices are socketed.

### System RAM

This memory consists of two 32K x 8 CMOS static RAMs with on-board expansion capability to 512K x 8 SRAMs.

### Non-Volatile Memory

This memory consists of a single 2K x 8 EEPROM and stores information which needs to be retained when the system is powered down. This includes user selectable operating parameters and a system error log.

## Safety Relevant Computing

This section addresses the Safety Relevant Computing (SRC) requirements of DIN V VDE 801. The electronic hardware design provides the necessary capability for meeting these requirements. This includes:

- Digital monitoring of selected control signals
- Analog monitoring of supply voltages, internal control voltages, feedback signals from the flow and inlet valves, and battery voltage
- Automatic switch-over to battery operation in the event of an interruption in ac power
- Use of the software watchdog timer in the 68340 processor for temporal monitoring, with direct de-energizing of the flow and inlet valves in the event of a non-recoverable error
- Use of an operating mode watchdog for logical and temporal monitoring, with direct de-energizing of the flow and inlet valves in the event of a non-recoverable error
- Monitoring of the system clock to detect an operating frequency out of an acceptable range
- Use of a redundant high pressure limit safety switch in the bellows drive circuit which directly de-energizes the flow valve

# Watchdog Systems

## 68040 Software Watchdog Timer

The watchdog timer in the 68340 processor activates for a time period appropriate for the application. If it times out due to a software execution fault (e.g. software trapped in an infinite loop), a level 7 interrupt (non-maskable) is internally issued so that the exception handler software can attempt to correct the error transparently.

## Operating Mode Watchdog

This watchdog detects errant program execution using an address matching technique as well as providing a time-out function. The time base for the temporal monitoring is independent from the system clock. Logical monitoring is accomplished by assigning a unique watchdog toggle address to each defined mode of operation and detecting a sequence error if, due to program flow interruption, an operating mode is entered illegally. The output of this watchdog is connected to IRQ7 on the 68340 processor.

## Error Response Sequence

Errors detected by either watchdog are handled in the following sequence:

- At the first detection of any error, a watchdog responds by issuing an IRQ7 interrupt.
- If the exception handler software for IRQ7 cannot correct the error, then the next detection of an error causes a soft system reset.
- If the error still cannot be corrected, then an audio alarm sounds (independent of processor interaction) and a cyclic soft reset continues until the error is corrected or the system is powered down.

## DATA Acquisition

The data acquisition system for the 7900 Ventilator consists of two major building blocks. The first is an analog to digital converter (ADC) system and the second is a digital to analog converter (DAC) system.

This portion of the 7900 Ventilator allows the Mercury microprocessor to interface with valves and pressure transducers. The data acquisition system is also used for internal monitoring of safety relevant signals.

The ADC system is designed to meet the following specifications:

- Resolution — 12 Bits
- Input Voltage Range — 0 - 4.095 Volts (1mV/LSB)
- Number of Channels — 16
- Total Conversion Time — 20u sec max
- Integral Nonlinearity — ± 1 LSB max
- Differential Nonlinearity — ± 1 LSB max (guaranteed monotonic)
- Full-Scale Error — ± 6 LSB max
- Unipolar Offset Error — ± 3 LSB max

The DAC system is designed to meet the following specifications:

- Resolution — 12 Bits
- Number of Channels — 1
- Settling time to 0.01% — 30u sec max
- Output Voltage Range — 0 - 4.095 Volts (1mV/LSB)
- Integral Nonlinearity — ± 1 LSB max
- Differential Nonlinearity — ± 1 LSB max (guaranteed monotonic
- Full-Scale Error — ± 9 LSB max
- Zero-Scale Error — + 4 LSB max

### Analog to Digital Converter System

The ADC system is based around the MAXIM MAX 191BCWG, a 12 Bit A/D converter. It operates from ± 15 Volt power supplies except for the A/D converter. The MAX191 is powered by a +5V supply and protected from over-voltage. The converter has an internal 4.096 Volt reference which results in a 1mV/Bit resolution.

A 16 channel multiplexer and buffer amplifier precedes the A/D converter. The manifold pressure, patient pressure, inspiratory flow and expiratory flow signal inputs to the multiplexer are filtered with an antialiasing filter. Other inputs are filtered by low pass filters.

Signals that are monitored by the ADC system include:

- Flow DAC output
- Flow Current sense
- Inlet Valve Current sense
- Patient Pressure
- Manifold Pressure
- Inspiratory Flow Sensor
- Expiratory Flow Sensor
- $O_2$ Concentration
- Power Supplies
- Battery Backup system

### Multiplexer and Buffer Amplifier

The multiplexer settles quickly, within 8 μ sec to 0.01%, to be stable for the ADC 12-Bit conversion and to maintain the overall 20 μ sec conversion time. The system bandwidth requirement is from dc to 20Hz. The multiplexer is an 8 channel fault protected device and the amplifier used as a buffer to drive the A/D converter (AD820AR).

### A/D Converter

The MAX191BCWG is a 12-Bit converter that operates from a single 5 Volt power supply. The clock frequency to run the A/D converter is 1.048MHz. It is derived from the microprocessor system clock.

With a 1.048MHz clock, the conversion time of the A/D converter is 13 clock periods or 12.4 μ sec, plus the 3 μ sec required for the track/hold amplifier. The resulting conversion time for the A/D converter is 15.4 μ sec.

The MAX191BCWG has the following unadjusted dc accuracy specifications:

- Integral Nonlinearity ± 1 LSB max
- Differential Nonlinearity ± 1 LSB max (guaranteed monotonic)
- Full-Scale Error ± 3 LSB max
- Unipolar Offset Error ± 2 LSB max

## Voltage Reference

Voltage reference is internal to the MAX191BCWG and adjusted with a potentiometer. This reference voltage is buffered and used for the digital to analog converter reference.

## Flow Valve Control

The flow valve control circuit consists of a D/A converter and a voltage to current conversion circuit.

### D/A Conversion

The D/A conversion for the flow valve drive circuit is based around the MAXIM MAX530BCWG 12-Bit DAC. The output of the DAC is fed to an input of the A/D converter multiplexer allowing the microprocessor to monitor the DAC output.

The MAX530BCWG is a 12-Bit D/A converter operates from a single 5 Volt power supply. The output range of the converter is 0 to 4.095 Volts (1mV per LSB).

The MAX530BCWG has the following dc accuracy specifications:

- Integral Nonlinearity ± 1 LSB max
- Differential Nonlinearity ± 1 LSB max (guaranteed monotonic)
- Full-Scale Error ± 1 LSB max
- Zero-Scale Error + 4 LSB max

### Flow Valve Drive Circuit

The Flow Valve Drive Circuit supplies flow valve current based on a given DAC input voltage setting. With a 0 to 4.000 Volts input, the drive circuit outputs 0 to 1.0 Amps typical into a 3 ohm load. This circuit does not require adjustment and is accurate within ± 2% of full scale.

This circuit also limits the flow valve output to less than 10VA under normal operation and under a single fault condition. This is a requirement of the international regulation IEC 601-2-13.

A signal representative of actual drive current is input to the A/D converter to allow the processor to monitor the current and detect faulty conditions.

## Gas Inlet Valve Drive Circuit

This circuit consists of a LM2952IM low-dropout regulator providing a regulated 5 Volts to the inlet valve when enabled by the microprocessor. The /SHUTDOWN pin of the regulator provides on/off control.

This regulator has an output current of 250mA. It has an internal current limit of 530mA max. This keeps the output under 10VA in a single fault condition and meets the 10VA requirements of IEC 601-2-13.

A current sensing circuit is included to allow the processor to monitor the inlet valve current via the A/D converter system and detect fault conditions.

## Front Panel Display Interface

All signals to and from the Front Panel are protected from ESD through the use of transient suppression devices and appropriate filtering. All of these signals are routed through a single connector from the microcontroller board to the front panel assembly.

### EL Display Controller

The S-MOS SED1351F Flat Panel display controller drives 480 horizontal pixels by 240 vertical pixels of the front panel EL display. Ferrite beads filter the signals from the display controller to the display.

### Video Display Memory

This memory consists of one high speed 32K x 8 CMOS static RAM directly connected to the SED1351F display controller, but mapped into 68340 memory space.

### Membrane Switch Inputs

These signals are electronically debounced and sampled by the 68340 processor.

### LED Driver Outputs

The ac on LED are turned on directly from the ac power applied and the mechanical ventilation LED is controlled by the glue logic. Both LEDs require no intervention from the microcontroller.

### Rotary Encoder Input

This quadrature signal is debounced and routed to a quadrature clock converter which interrupts the 68340 processor at each detent position.

### Mechanical Ventilation Switch

This switch is electronically debounced and it inputs to a hardware latch which toggles between set and reset states with each depression of the switch. The output of this latch directly drives the ventilation state LED on the front panel as well as controlling the drive signal to the flow valve independent of the processor. The latch is reset by the power-up (hard) reset signal, an IRQ7 Interrupt, a processor control signal, or a switch depression. The state of this latch as well as the direct switch signal is input to the 68340 processor for monitoring purposes.

## Audio Alarm

The audio alarm meets the requirements of the ISO standard 9703-2, "Anesthesia and Respiratory Alarm Signals: Part 2, Auditory Alarm Signals".

The circuit consists of a Yamaha YM2413 Sound Generator and a National Semiconductor LM4860M audio amplifier. The sound generator interfaces directly to the CPU and the audio amplifier drives an 8 ohm speaker.

## Manifold Pressures

A Setra pressure sensor (model 210 PCBM) monitors manifold pressure. It is located in the oxygen isolation barrier between the electronics and pneumatics chambers.

The signal conditioned pressure transducer outputs are:

| | |
|---|---|
| Manifold pressure: | -20 to 120 $\pm$ 1.5 $cmH_2O$, less than 30 $cmH_2O$; |
| | -20 to 120 $\pm$ 5% $cmH_2O$, greater than 30 $cmH_2O$ |

## Front Panel Assembly

The front panel assembly has a 480 by 240 pixels EL panel that displays measured and user adjustable parameters. The user can change parameters with touch switches on the membrane or a rotary encoder with a switch. LED's are incorporated in the membrane switch to indicate alarms, mechanical ventilation On/ Standby and Mains power.

# Sensor Interface Board (SIB)

The Sensor Interface Board, (SIB), is the interface for the ventilator control module and the anesthesia machine. It is designed to be used in the Excel models 110 SE, 210 SE's, and Modulus SE.

The SIB is located in the anesthesia machine below the work surface table top. Input air hoses and signal cables are routed from the side panel of the machine to the board. A 50 conductor SCSI II cable routes power and signals to and from the Ventilator.

Respiratory gas flow to and from the patient is measured in the machine by creating a small differential pressure across a calibrated variable orifice. The transducers for measuring the differential pressure are on the SIB. The delivered patient airway gas pressure is also measured by a pressure transducer on the SIB. In addition, conditioning circuitry is provided for these transducers and for the Oxygen sensor. For noise immunity, the signal outputs from the board are transmitted as 20 mA current signals.

### Inspiratory and Expiratory Flow Measurement

Differential pressure levels of up to ±- 3.5 $cmH_2O$ are applied to the differential pressure transducers by the flow of gasses past the variable orifice. This produces dc output voltages in the range of 0.200 to 2.700 volts, with zero pressure producing 1.450 volts at the transducer, and 2.000 volts at the A/D controller in the Ventilator. Calibration data is stored in an EEPROM in each of these sensors. When directed by system software, a differential clock signal is sent to the SIB where it is transformed into a single ended signal for the EEPROMS. An enable signal is also sent that turns on 5 Vdc power. For noise immunity, when the data has been read by the microcontroller board in the ventilator, these signals are turned off.

### Patient Airway Pressure Measurement

When there is gas flow in the system, the voltage produced by the differential pressure transducer is applied to a current transmitter IC. Used in the 0 to 20 mA mode, its full scale input range is 2.500 Vdc. In order to exactly match the transducer output range, the current transmitters are offset by 0.200 Vdc. This is done by using the 2.000 volt reference generated by one of the IC's. The reference voltage is reduced through a voltage divider and applied as a low impedance source by using a buffer amplifier stage. This arrangement allows a full scale output swing of 0 to 20 mA, for an input of 0.200 to 2.700 Vdc.

Patient Airway Pressure is measured off the high side of the inspiratory transducer. A pressure range of -20 to + 120 $cmH_2O$ produces a proportional dc output voltage in the range of 0.050 to 4.050 volts, with zero pressure producing 0.621 volts. This voltage is reduced by a voltage divider and applied to a current transmitter as described above, with the exception that no offset voltage is used.

### O2 Concentration Measurement

The Oxygen sensor generates a linear output voltage that depends upon the concentration being measured. It produces an output of 57 ±- 14 mV dc at 100% concentration, therefore its output is amplified by a factor of 52 to make it compatible with the current transmitter. This produces a maximum output of 2.50 volts.

The 0 to 20 mA current signals are sent to the Ventilator where a voltage drop is produced across 200 ohm resistors, for a 0 to 4.00 volt signal to be measured by the A/D converter.

### Switch Connections

The SIB is used as a connection point for the various switches that indicate the state of the machine. These include the $O_2$ flush, the Power On switch, the DCGO switch fitted to French SE anesthesia machine, and the $O_2$ pressure switch mounted on the SIB.

## Notes:

# 3/Post Service Checkout

After servicing the ventilator, run any service menu tests that are pertinent to the components replaced; Perform calibration on Flow sensors, Pressure sensitivity, Flow valve and Bleed resistor. You must complete the checkout procedure for the entire system; the ventilator, the anesthesia system, and all the accessories and options.

**WARNING:** ⚠ **You must perform all post-service checks after maintenance or service of the ventilator. Failure to do so may result in patient injury.**

**WARNING:** ⚠ **All components and accessories must be connected correctly. All hoses and cables must be properly connected before returning the anesthesia system to clinical use. Failure to do so may result in patient injury.**

## 3.1. Test the Ventilator.

Perform section "Preoperative checkout procedure" found in the Anesthesia System Operation and Maintenance Manual.

## 3.2. Test the Anesthesia System.

The ventilator is an integral part of a complete anesthesia system. To be certain the ventilator is functioning correctly it is necessary to test the entire system. Please refer to the anesthesia system manuals.

**Important**: If you have an Ohmeda Excel SE Anesthesia System, complete the system checkout procedure in the Excel SE Service Manual. If you have an Ohmeda Modulus® SE Anesthesia System, complete the system checkout procedure in the Modulus® SE Service Manual.

## 3.3. Test all Options and Accessories.

Complete the checkout procedures for all options and accessories included with the anesthesia system.

## Notes:

# 4/Tests and Troubleshooting

## 4.1. Overview

**WARNING:** ⚠ **Do not perform testing or maintenance on medical instruments while they are being used on a patient; patient injury may result.**

This section includes pass and fail tests with calibration procedures for 7900 Ventilator control module. Operator calibration information is covered in the 7900 Ventilator O&M manual.

### Testing Requirements

The 7900 Ventilator, an integral part of the Ohmeda Anesthesia System, can be tested while the control module is mounted in the anesthesia machine. From the test results, you must determine if it is necessary to remove the control module to gain access for service and/or maintenance.

The ventilator must be removed from the anesthesia system and placed on a special service shelf in order to gain access for service, maintenance and parts replacement. This service shelf allows you to set the ventilator on the work surface of the anesthesia system and reconnect hoses and cables.

If you are performing routine maintenance it is necessary to complete the entire section. It is always necessary to perform section "3/Post-Service Checkout" after this section.

**WARNING:** ⚠ **Post-Service Checkout is required after you complete this section. You must perform section " 3/Post-Service Checkout" after performing any maintenance, service or repair. Failure to do so may result in patient injury.**

The 7900 Ventilator has a self test built into its software. This test determines that the software is functioning properly and that the electronic circuits on the circuit boards are functional.

The following list of the tests run at power-up:

- *Sequential watchdog
- *Logical watchdog
- *Data RAM walking pattern test
- *FLASH ROM CRC verification
- Gas inlet valve test (electrical and pneumatic)
- Calibration of the manifold sensor

If the gas inlet valve causes the self test to fail on power up an alarm occurs and is displayed appropriately "Gas Inlet Valve Circuit Failure" Also an error code (1002C) will register on the error code service mode menu.

If the calibration of the manifold sensor fails on power up, an alarm occurs and is displayed appropriately "Manifold Pressure Sensor Failure". An error code (1003E) will also register on the error code service mode menu.

*If one or more of these tests fail, the display provides a readout which tells the operator to contact an Ohmeda Service Representative.

These tests are run continuously during normal operation and alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area. See section 4.7 of this chapter and the Appendix in the O&M Manual.

- Flow valve electrical feedback
- Gas inlet valve electrical feedback
- Supply voltage checks
- Battery voltage checks

These tests are run periodically (every 30 seconds) during normal operation and alarms are associated with each test. A failure causes an alarm to display on the screen in the alarm display area. See section 4.7 of this chapter and the Appendix in the O&M Manual.

- CPU Test
- Display RAM walking pattern test
- Data RAM walking pattern test
- FLASH ROM CRC verification

This test runs only at boot up when mechanical ventilation is turned off:

- Gas inlet valve (electrical and pneumatic)

If the gas inlet valve fails on power up, an alarm occurs and is displayed appropriately "Gas Inlet Valve Circuit Failure" Also an error code (1002C) will register on the error code service mode menu.

If the self test has passed, the remainder of the service troubleshooting is checking the system visually and running the tests from the Service Mode Menu.

## 4.2. Service Mode Menu

The service calibration mode tests and/or calibrates hardware necessary to prepare a ventilator in the plant for factory shipment and to service a ventilator in the field. Tests may be run manually with the rotary encoder (also called the adjustment knob).

To enter this service mode, push and hold in the adjustment knob at power-up until the "Service Confirmation" menu appears. Then select "Service Mode" from this menu.

Another method to access the service mode is by a three key reboot. This method can be used when the ventilator is in the normal operating mode. Ensure the Mechanical Ventilation switch is off, Apnea Detect Off and Volume Monitor Standby modes are selected. Press the $V_T$/Press., PEEP, and the menu switches at the same time. Then push and hold the adjustment knob until the "Service Confirmation" menu appears. The ventilator enters the service mode without having to power down and then back up.

All data displayed by the ventilator during and after a service mode test or measurement is also output to the serial port.

The service mode has a top level main menu screen which displays all the selectable service tests in categorical order; Diagnostic Tests/ Tools, Calibrations and User settings. Any service test can be selected from this menu with the adjustment knob cursor. Software version and a date code are at the top of the screen.

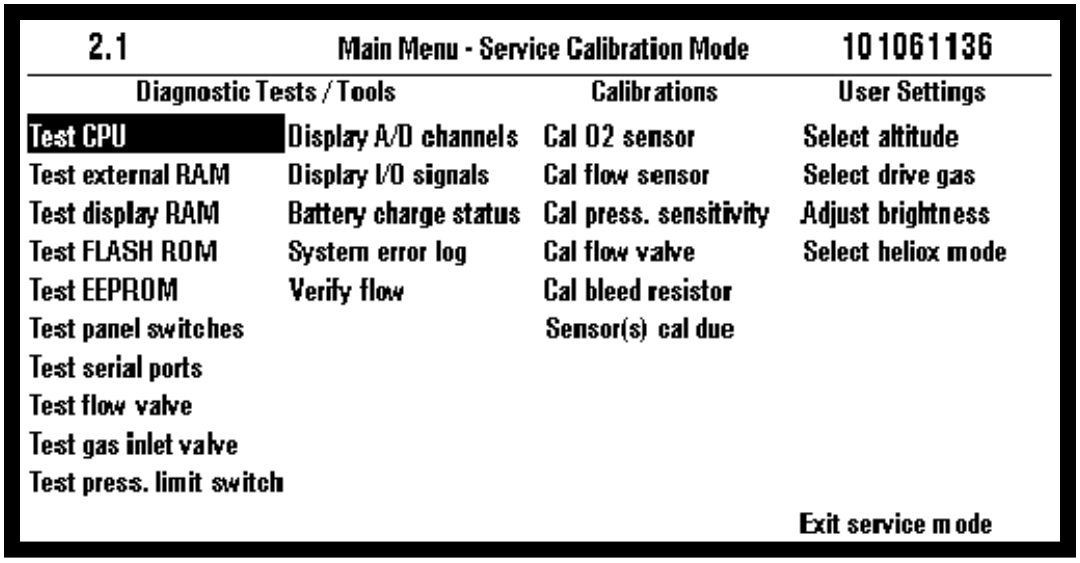



**Figure 4-1**
Service mode main menu

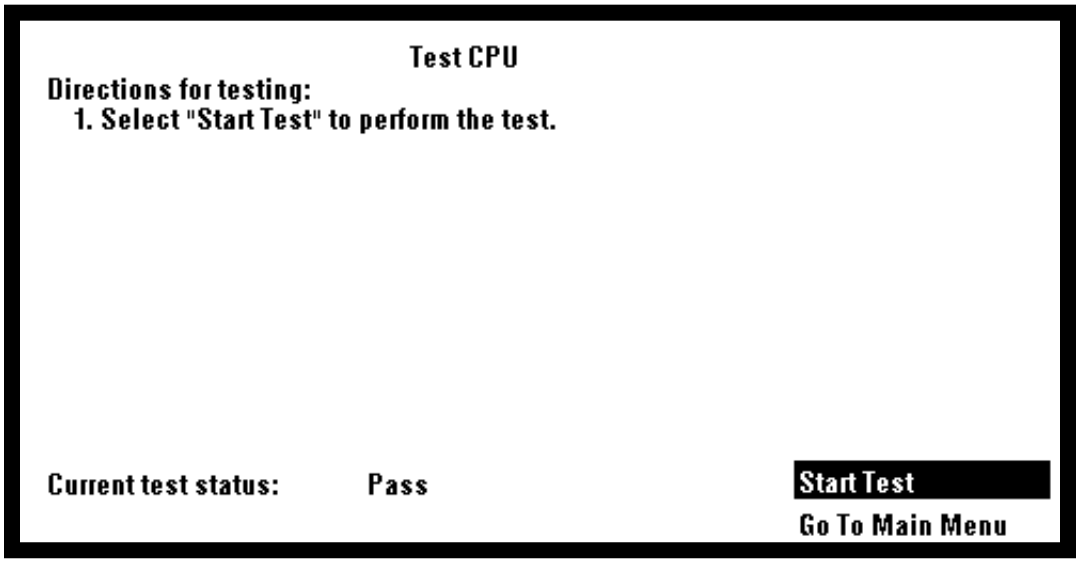
# 4.3. Diagnostic Tests

**Note:** For simplicity the following text uses the term control wheel for the knob used to select and confirm settings  This knob and the rotary encoder switch attached are also referred to as "The Encoder".

## Test CPU

The software tests the CPU integer instructions as well as the CPU register(s).  If this test fails, the CPU did not perform an integer instruction correctly, or the CPU register(s) have failed.

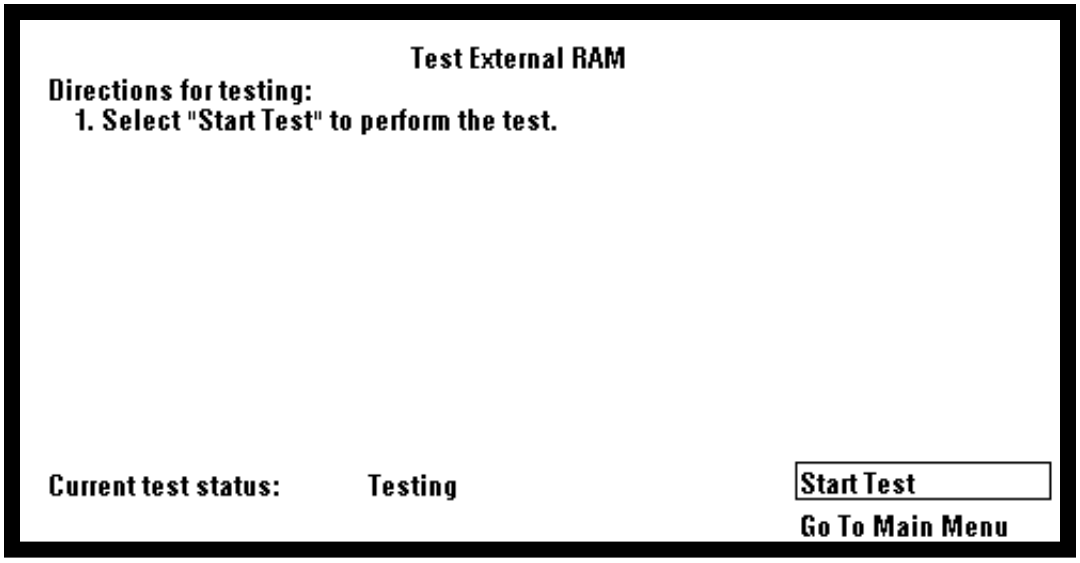
Upon FAIL, replace the microcontroller board - See section 6.



## Test External RAM

The software tests all of the external RAM memory with a walking bit pattern test. It writes a certain bit pattern to a block of memory and then reads that block of memory. If the bit pattern that it wrote is not the same bit pattern that it reads back the test fails.

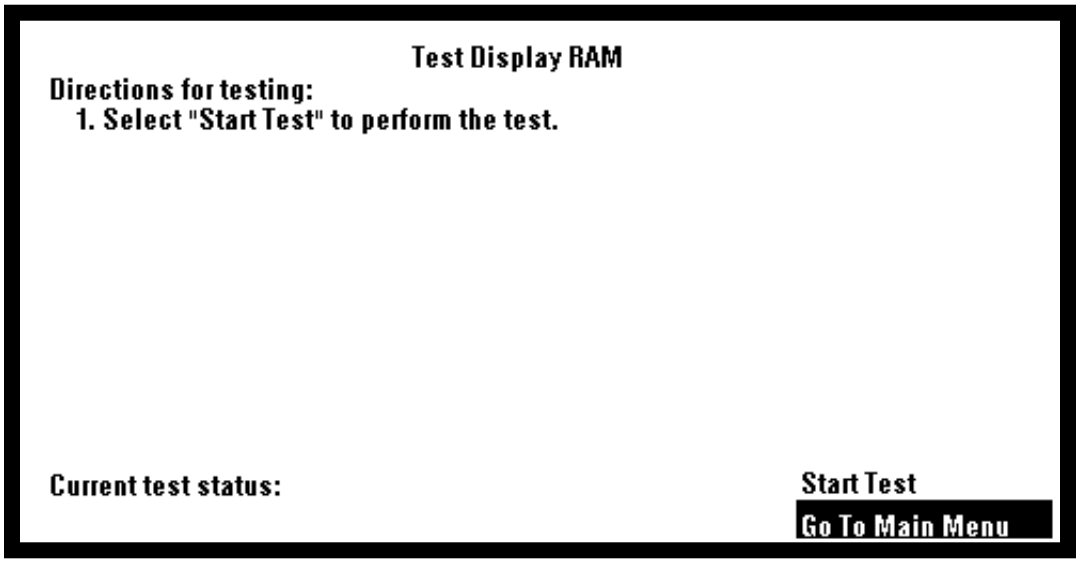
Upon FAIL, replace the microcontroller board - See section 6




## Test Display RAM

The software tests all of the display RAM memory via a walking bit pattern test. It writes a certain bit pattern to a block of memory and then reads that block of memory. If the bit pattern that was written is not the same bit pattern that it reads back the test fails.

Upon FAIL, replace the microcontroller board.

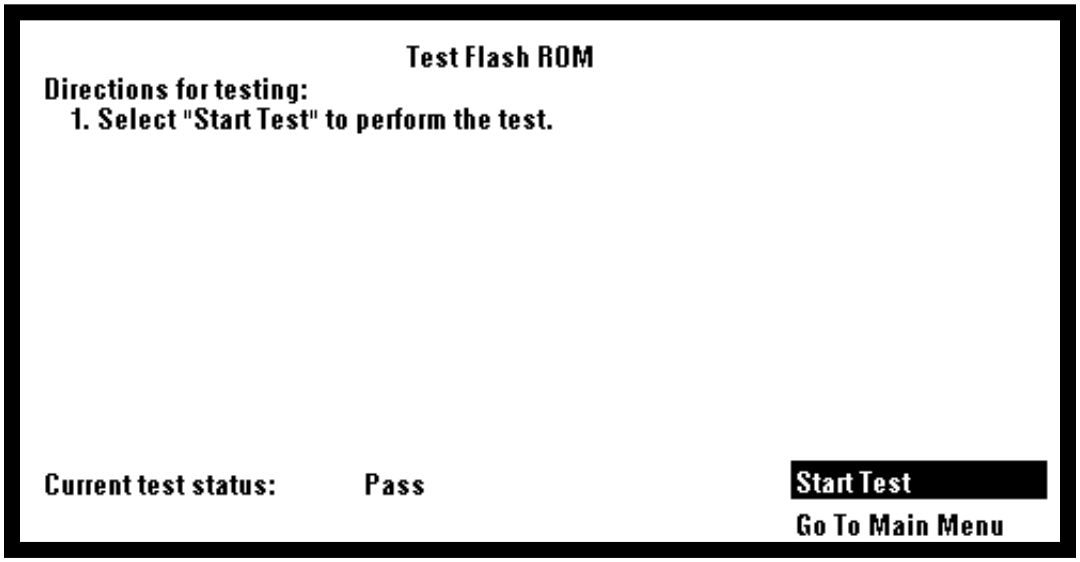


## Test Flash ROM

The software tests the Flash ROM via a CRC check (Cyclic Redundancy Check). A CRC value has been calculated for the Flash ROM memory and this value is stored in the Flash ROM. This test recalculates the CRC for the Flash ROM and compares it to the value stored in Flash ROM. If the value that was calculated does not equal the value that was stored in Flash ROM, the test will fail.

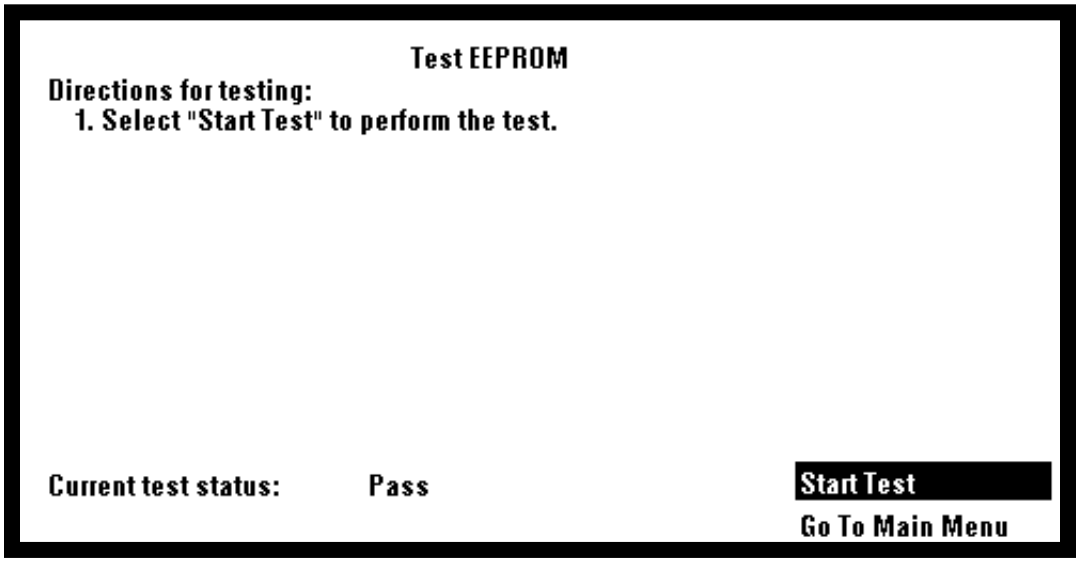
Upon FAIL, replace the microcontroller board software.

(a new Flash ROM chip) see section 6.



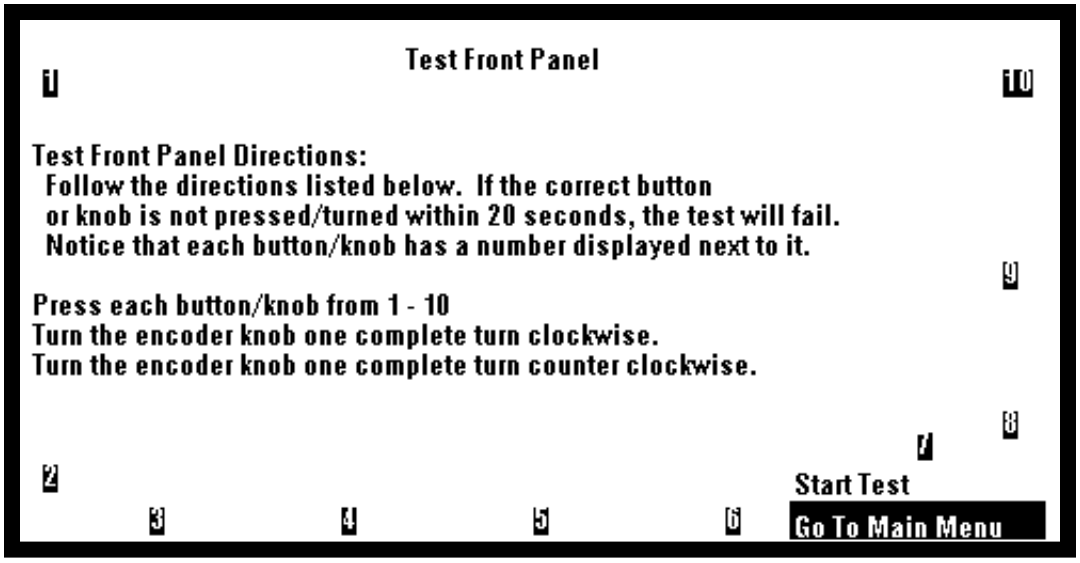
## Test EEPROM

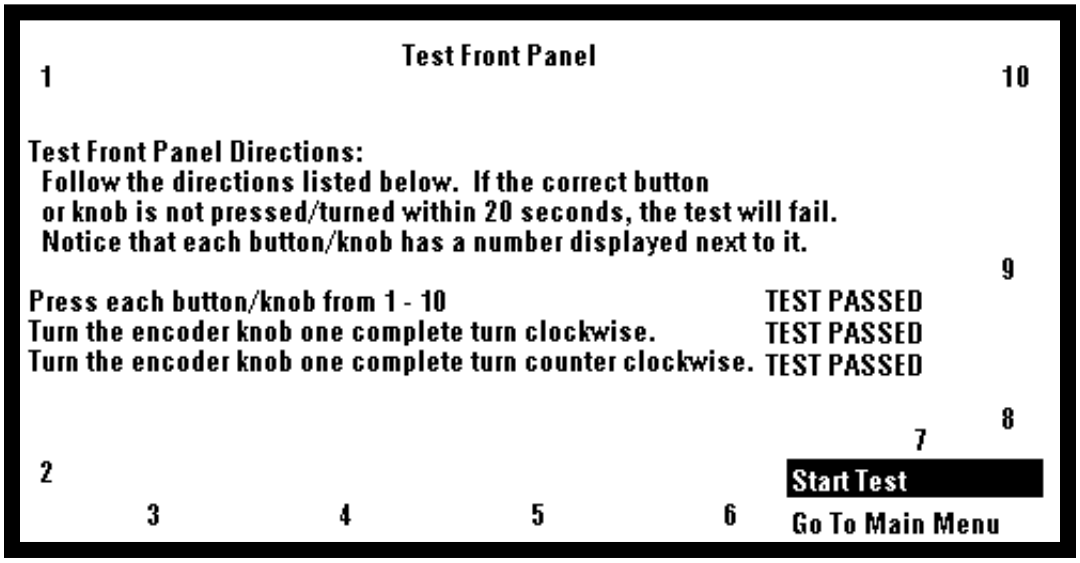
The software tests all of the EEPROM memory via a bit pattern test. It writes a certain pattern to a block of memory and then reads that block of memory. If the bit pattern that was written is not the same as the bit pattern read back, the test fails. Upon FAIL, replace the microcontroller board.

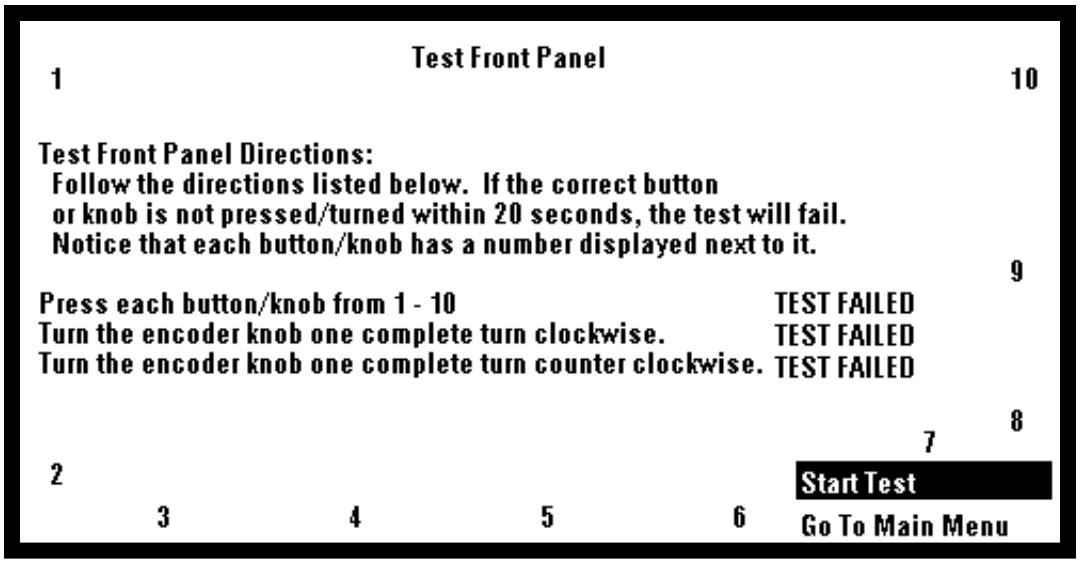


## Test Panel Switches

The software will set up the ventilator to receive all button presses and control wheel turns. The test asks the user to press each of the buttons and turn the control wheel one full turn in both directions. Each time a button is pressed the number next to the button is reverse-highlighted. If the button is pressed and the number next to the button does not reverse highlight the test for that button failed. If all of the buttons are pressed and all of the numbers next to the buttons are reverse-highlighted the button press test passes. The control wheel turn test works the same way. The user is prompted to turn the control wheel clockwise and counter-clockwise one full turn (16 clicks). When the control wheel is turned (one full turn in either direction) and the control wheel is working, the test passes. If the control wheel is not working, the test times-out in about 10 seconds and the test fails.


Test Front Panel
1
10
Test Front Panel Directions:
Follow the directions listed below. If the correct button
or knob is not pressed/turned within 20 seconds, the test will fail.
Notice that each button/knob has a number displayed next to it.
9
Press each button/knob from 1 - 10
Turn the encoder knob one complete turn clockwise.
Turn the encoder knob one complete turn counter clockwise.
8
7
2
Start Test
3
4
5
6
Go To Main Menu


Test Front Panel
1
10
Test Front Panel Directions:
Follow the directions listed below. If the correct button
or knob is not pressed/turned within 20 seconds, the test will fail.
Notice that each button/knob has a number displayed next to it.
9
Press each button/knob from 1 - 10 TEST PASSED
Turn the encoder knob one complete turn clockwise. TEST PASSED
Turn the encoder knob one complete turn counter clockwise. TEST PASSED
8
7
2
Start Test
3
4
5
6
Go To Main Menu

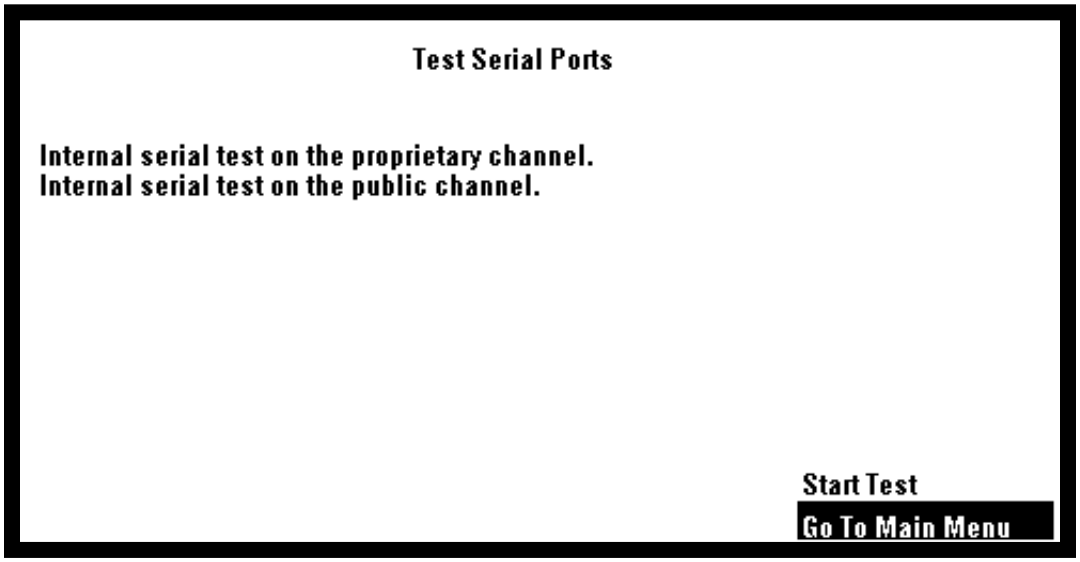


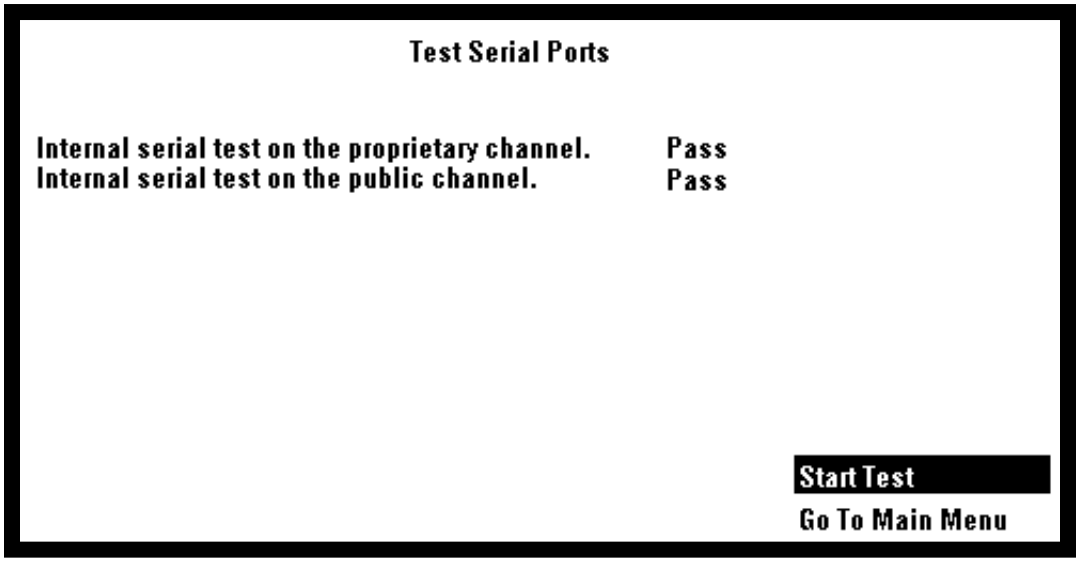

**Panel Switch FAIL Instructions:**

If any of the select buttons or the adjustment knob turn test fails, replace the front panel board or the control wheel.

## Test Serial Ports

The software performs an internal test on both of the serial ports. The software sets up the serial ports so any data sent out the serial ports is echoed directly back to that serial port. The test fails if the data sent out is not equal to the data received. The status of the test is displayed on the ventilators front screen.


Test Serial Ports
Internal serial test on the proprietary channel.
Internal serial test on the public channel.
Start Test
Go To Main Menu

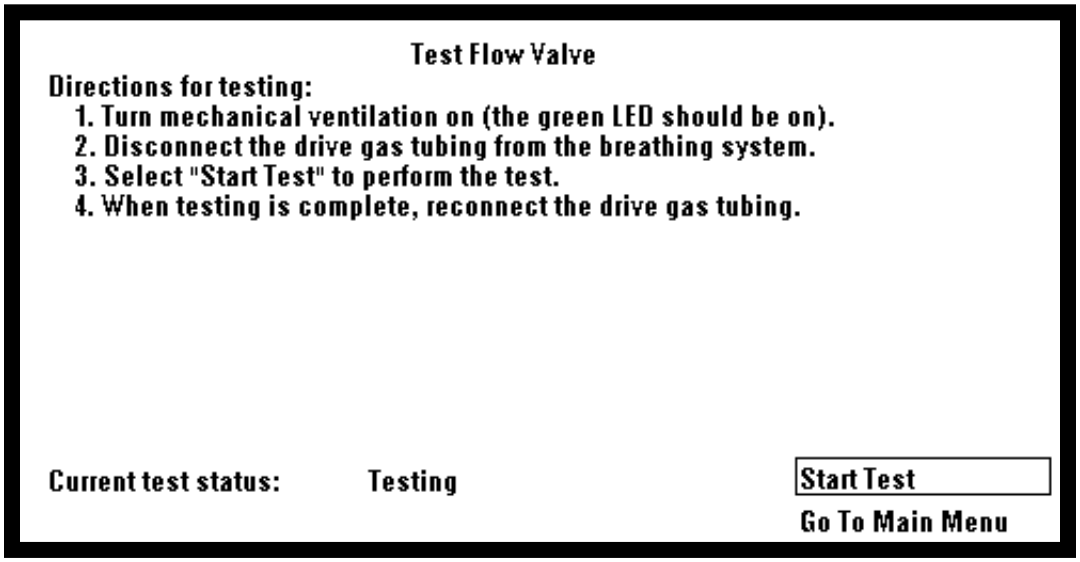

Test Serial Ports
Internal serial test on the proprietary channel. Pass
Internal serial test on the public channel. Pass
Start Test
Go To Main Menu

### Serial Port FAIL Instructions

The software checks the serial ports to ensure any data sent out is looped back as a direct echo. If the returned data is not the same as that sent, the ports fails. Replace the microcontroller board.

## Test Flow Valve

To test the flow valve the software starts off by closing the flow valve. It then opens the flow valve in increments until the flow valve is completely open. At each of the settings of the flow valve the A/D (Analog/Digital) channel for Flow DAC (Digital to Analog Converter) Feedback and Flow Current Sense will be read. If the A/D for the Flow DAC Feedback and Flow Current Sense are not within the correct tolerance the test fails.

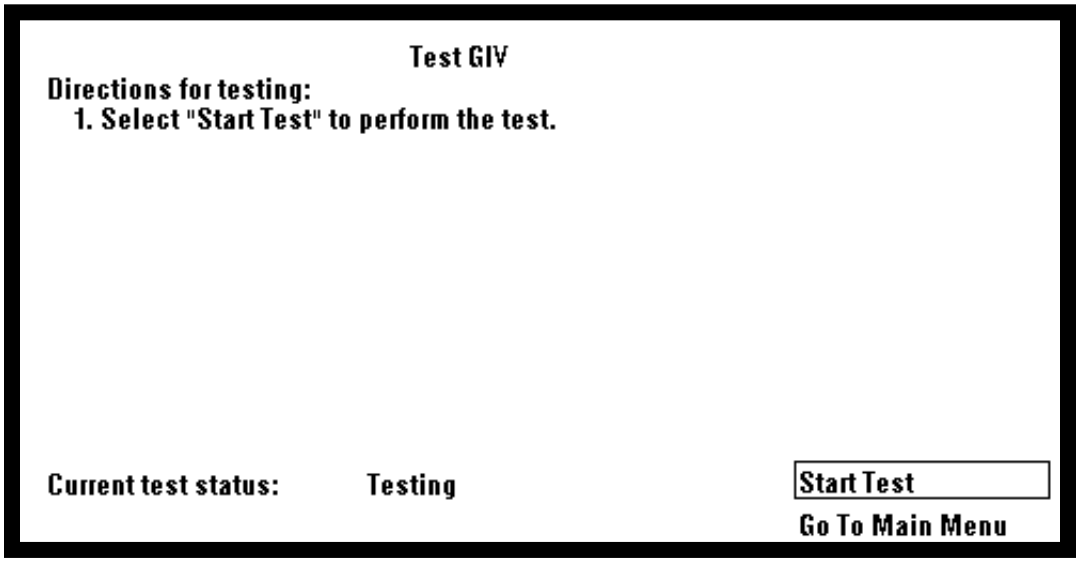

Test Flow Valve
Directions for testing:
1. Turn mechanical ventilation on (the green LED should be on).
2. Disconnect the drive gas tubing from the breathing system.
3. Select "Start Test" to perform the test.
4. When testing is complete, reconnect the drive gas tubing.
Current test status:
Testing
Start Test
Go To Main Menu

A failure can be caused either by the drive circuit or the flow valve malfunction. Check the drive circuit. Check the flow valve.

To check the drive circuit for proper voltage, set the flow control to output 120 liters per minute. Unplug the connector from the microcontroller board and measure the voltage between the pins, it should be approximately 3 volts. If the voltage is less than 3 volts, measure the resistance between the leads at the unplugged flow valve connector. A multimeter should read 3 ohms, ± one percent. If the resistance is 3 ohms, the drive circuit is bad, replace the microcontroller board and test the flow valve again. If the flow valve test fails again, replace the flow valve.

## Test Gas Inlet Valve (GIV)

To test the gas inlet valve the software first closes the GIV. It then reads the A/D for the GIV. If the A/D for the GIV does not read closed, the test fails. The software then opens the flow valve to the calibrated flow of the bleed resistor. Then it waits for the flow to stabilize (about 2 seconds). Once the flow is stabilized the software checks to see if manifold pressure has dropped to less then 0.5 $cmH_2O$. If manifold pressure does not drop below 0.5 $cmH_2O$, the test fails. The software then closes the flow valve and opens the GIV. It then reads the A/D for the GIV and if the A/D for the GIV does not read open, the test fails.




### Gas Inlet Valve FAIL Instructions:

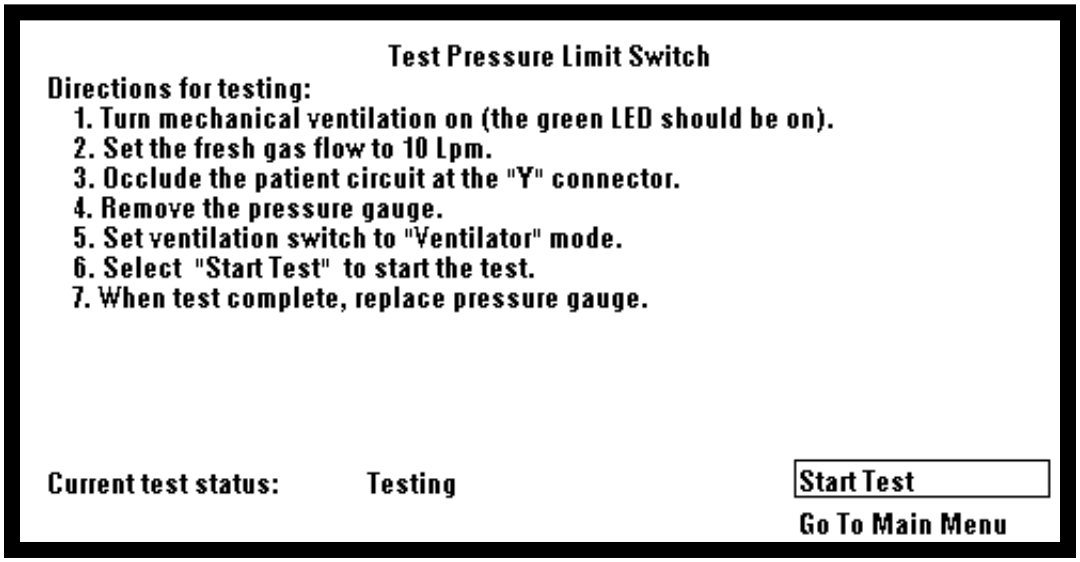
Failure can be caused by the valve malfunctioning or the microcontroller board.

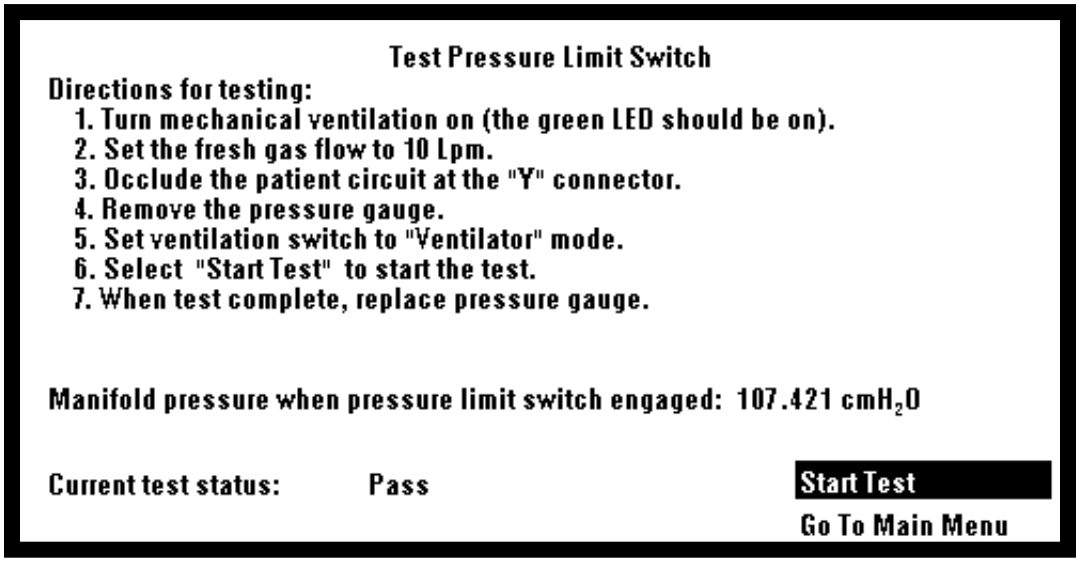
Use a multimeter to measure the resistance of the GIV solenoid. It should be approximately 25 ohms. If necessary, replace the GIV solenoid.

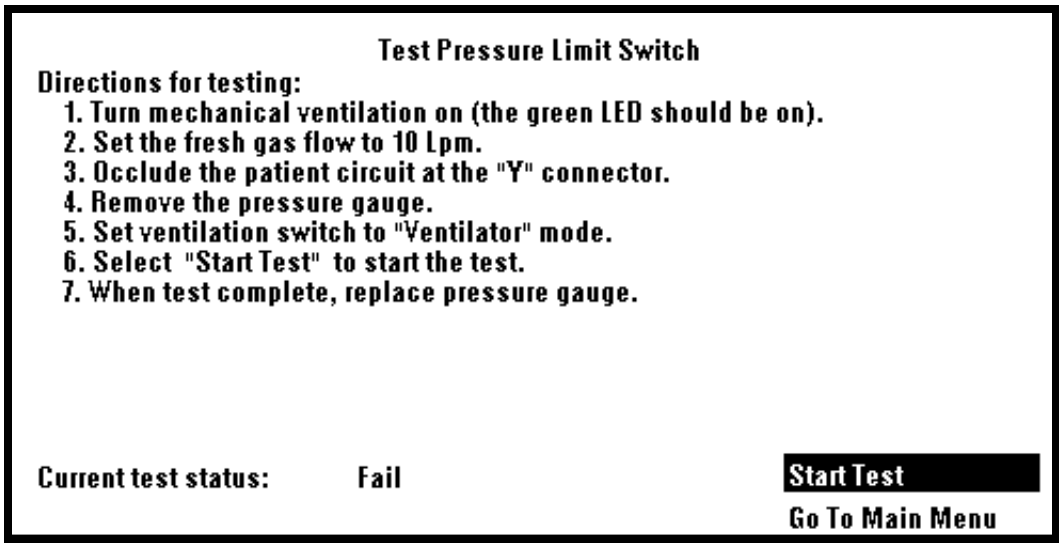
Use a multimeter to measure the voltage at the inlet valve connector which plugs into the microcontroller board. The voltage should be 4.5 volts when the GIV is open. If the voltage is 4.5 volts or greater, rebuild the GIV. If the voltage is less than 4.5 volts replace the microcontroller board.

## Test Pressure Limit Switch

The software tests the pressure limit switch to make sure that it trips at the correct manifold over pressure. The software opens the flow valve to a value where pressure continues to increase. It then waits for the DPL (Drive Pressure Limit) switch to trip. The pressure at which the DPL switch tripped is indicated. This value is calculated manifold pressure (the typical reading is 112 $cmH_2O$) not the actual pressure at the switch. If the DPL switch never trips (within 15 seconds) the test fails. If the DPL switch does not trip at a pressure within the correct tolerance, the test fails.


Test Pressure Limit Switch
Directions for testing:
1. Turn mechanical ventilation on (the green LED should be on).
2. Set the fresh gas flow to 10 Lpm.
3. Occlude the patient circuit at the "Y" connector.
4. Remove the pressure gauge.
5. Set ventilation switch to "Ventilator" mode.
6. Select "Start Test" to start the test.
7. When test complete, replace pressure gauge.
Current test status: Testing
Start Test
Go To Main Menu


Test Pressure Limit Switch
Directions for testing:
1. Turn mechanical ventilation on (the green LED should be on).
2. Set the fresh gas flow to 10 Lpm.
3. Occlude the patient circuit at the "Y" connector.
4. Remove the pressure gauge.
5. Set ventilation switch to "Ventilator" mode.
6. Select "Start Test" to start the test.
7. When test complete, replace pressure gauge.
Manifold pressure when pressure limit switch engaged: 107.421 $cmH_2O$
Current test status: Pass
Start Test
Go To Main Menu


Test Pressure Limit Switch
Directions for testing:
1. Turn mechanical ventilation on (the green LED should be on).
2. Set the fresh gas flow to 10 Lpm.
3. Occlude the patient circuit at the "Y" connector.
4. Remove the pressure gauge.
5. Set ventilation switch to "Ventilator" mode.
6. Select "Start Test" to start the test.
7. When test complete, replace pressure gauge.
Current test status: Fail
Start Test
Go To Main Menu

### Pressure Limit Switch FAIL Instructions:

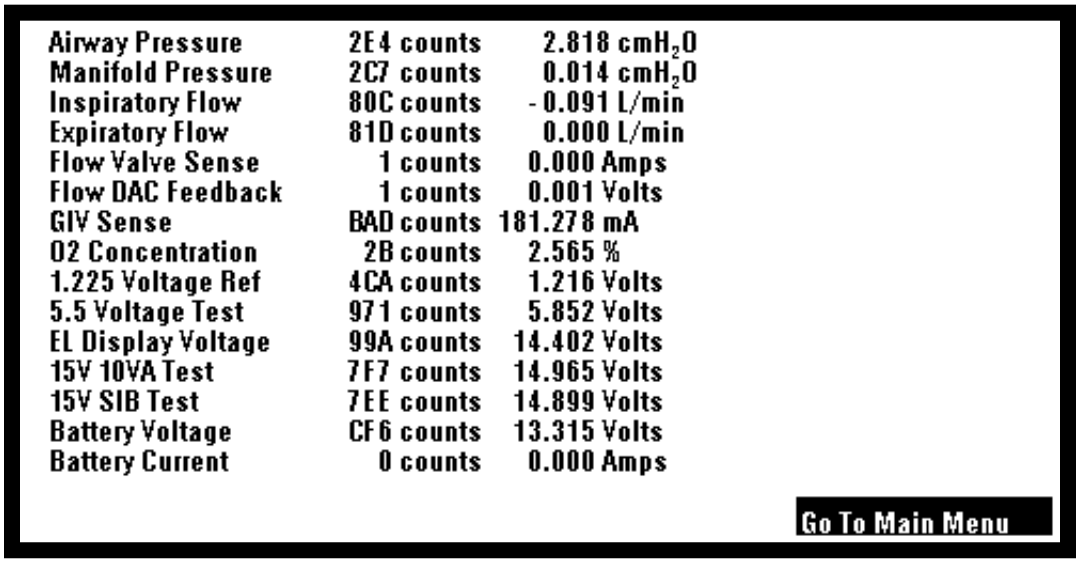
Go to the Discrete I/O signal menu and check the DPL (Drive Pressure Limit) switch status. Disconnect pressure switch tubing from manifold and apply 104 $\pm$ 4 cmH2O to activate switch and verify switch status. If signal status does not agree with switch status, disconnect J8 on microcontroller board and measure resistance to determine function of switch.

# 4.4. Diagnostic tools

## Display A/D channels

The software displays the A/D values for each of the A/D channels.

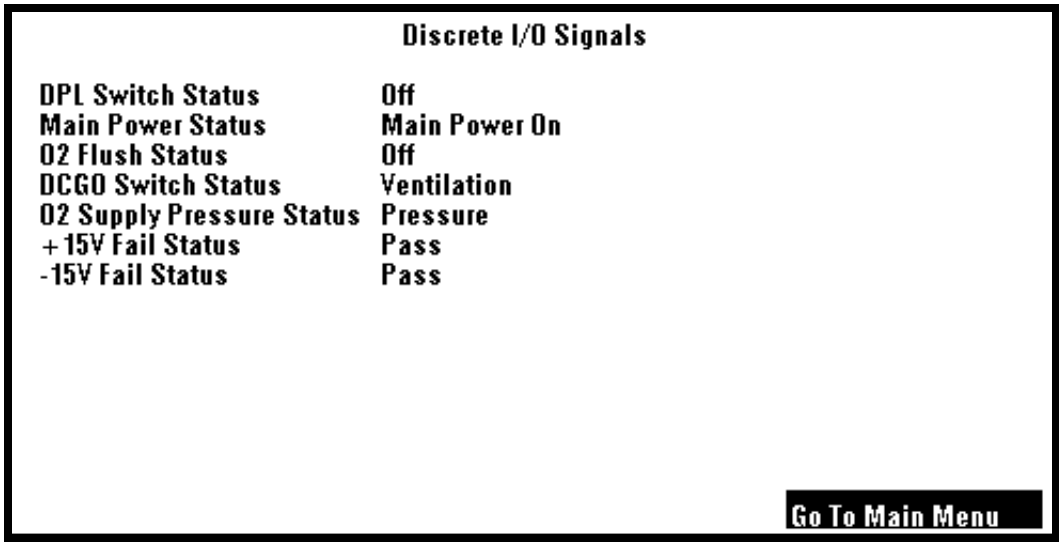
**Remarks**: This selection displays a listing of A/D Channels which are at various values depending upon the set parameters. One check that can be made is a disconnect check or large leak check.


Airway Pressure 2E4 counts 2.818 cmH2O
Manifold Pressure 2C7 counts 0.014 cmH2O
Inspiratory Flow 80C counts - 0.091 L/min
Expiratory Flow 81D counts 0.000 L/min
Flow Valve Sense 1 counts 0.000 Amps
Flow DAC Feedback 1 counts 0.001 Volts
GIV Sense BAD counts 181.278 mA
O2 Concentration 2B counts 2.565 %
1.225 Voltage Ref 4CA counts 1.216 Volts
5.5 Voltage Test 971 counts 5.852 Volts
EL Display Voltage 99A counts 14.402 Volts
15V 10VA Test 7F7 counts 14.965 Volts
15V SIB Test 7EE counts 14.899 Volts
Battery Voltage CF6 counts 13.315 Volts
Battery Current 0 counts 0.000 Amps
Go To Main Menu

| DESCRIPTION | ACTUAL RANGE | HEX RANGE | DISPLAYED RANGE | UNITS | SPECIAL INSTRUCTIONS |
|---|---|---|---|---|---|
| | | | | | |
| PATIENT PRESSURE | -20 to + 120 cmH2O | 0209-02D1 | 18.235-25.235 | cmH2O | Zero Offset Reading (nominal 621 LSB) |
| MANIFOLD PRESSURE | -20 to +120 cmH2O | 0209-02D1 | 18.235-25.235 | cmH2O | Zero Offset Reading (nominal 621 LSB) |
| INSPIRATORY FLOW | -3.5 to +3.5 cmH2O | 0726-0924 | 3.66-4.68 | cmH2O | Zero Offset Reading (nominal 2050 LSB) |
| EXPIRATORY FLOW | -3.5 to +3.5 cmH2O | 0726-0924 | 3.66-4.68 | cmH2O | Zero Offset Reading (nominal 2050 LSB) |
| FLOW CURRENT SENSE | 0 to 1 Amp | 0000-0FFF | 0-1.023 | Amps | |
| FLOW DAC FEEDBACK | 0 to 4.095 Volts | 0000-0FFF | 0-4.095 | Volts | |
| INLET VALVE CURRENT SENSE | 0 to 200 MA | 0943-0F2C | 0-235 | milliamps | Off State Reading = 0 to 259 LSB |
| O2 CONCENTRATION | 0 to 100% | 0000-0FFF | 1-100 | % | |
| 1.225V VOLTAGE REFERENCE | 1.220V to 1.229V | 04BE-04D3 | 1.214-1.235 | Volts | |
| 5.5V TEST | 4.988 to 6.09 Volts | 07D7-09FB | 4.025-6.214 | Volts | |
| +12V EL SUPPLY TEST | 10 to 15 Volts | 0677-0A41 | 10.667-15.402 | Volts | |
| +15V LOCAL10VA TEST | 13.75 to 15.75 Volts | 071A-089F | 13.351-16.207 | Volts | |
| +15V SIB TEST | 13.75 to 15.75 Volts | 071A-089F | 13.351-16.207 | Volts | |
| BATTERY VOLTAGE TEST | 0 to 16 Volts | 0000-0FFF | 0-16.446 | Volts | <7V = No Battery<br><12.5V On AC = Low Battery<br><11.35V On BATT = Low Battery<br><10.9V ON BATT = Low Batt Shutdown<br><16V = Batt Out Of Range |
| BATTERY CURRENT TEST | 0 to 4 Amps | 0000-0FFF | 0-4.095 | Amps | >300mA = On Battery<br>>4Amps = Out Of Range |
| ANALOG GROUND | 0 to LSB | 0000-0006 | 0-0.006 | Volts | |

## Display I/O signals

The software will display all of the I/O signals.




**Remarks**

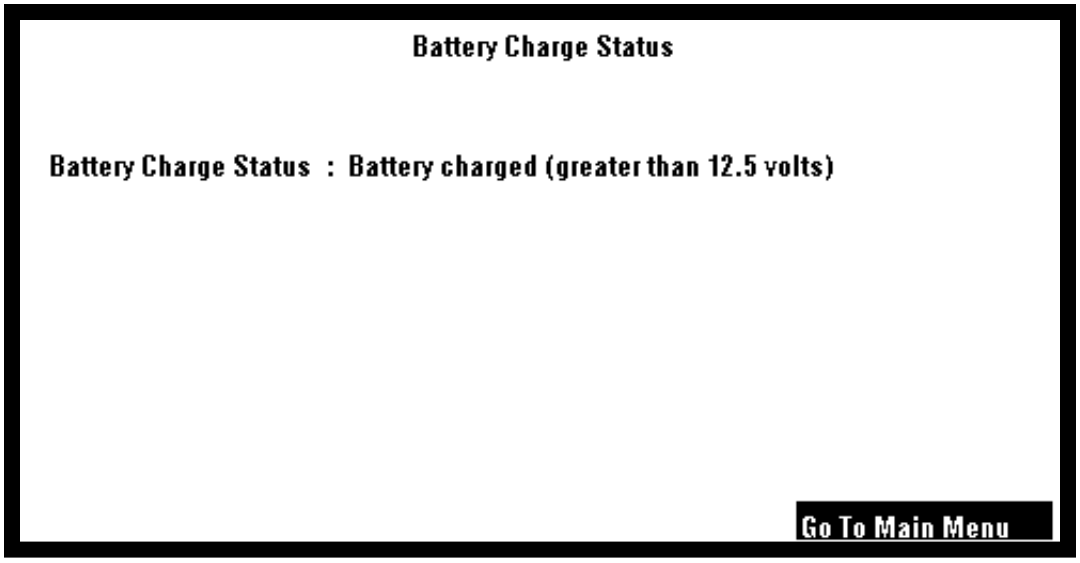
This display is a service tool for:

- DPL switch status - shows off unless drive pressure has exceeded limit (switch is N.O.)
- $O_2$ flush switch status - shows on or off when pushing and releasing gas machine $O_2$ flush valve
- DCGO switch status - French machines only either Vent or Aux
- $O_2$ Supply Pressure Status - Pressure indicates there is $O_2$ supply pressure
- +15V Fail Status - indicates analog positive voltage supplies are within range
- -15V Fail Status - indicates analog negative voltage supplies are within range

## Display Battery Charge Status

The software displays the battery charge status. This checks to see if the battery charge is greater than or equal to 12.5 volts. If it is less than 12.5 volts, the battery charge status displays that the battery is not charged. If it is greater than or equal to 12.5 volts, the battery charge status displays that the battery is charged.

Battery Charge Status: Battery Charged (greater than 12.5 volts)




**Remarks**

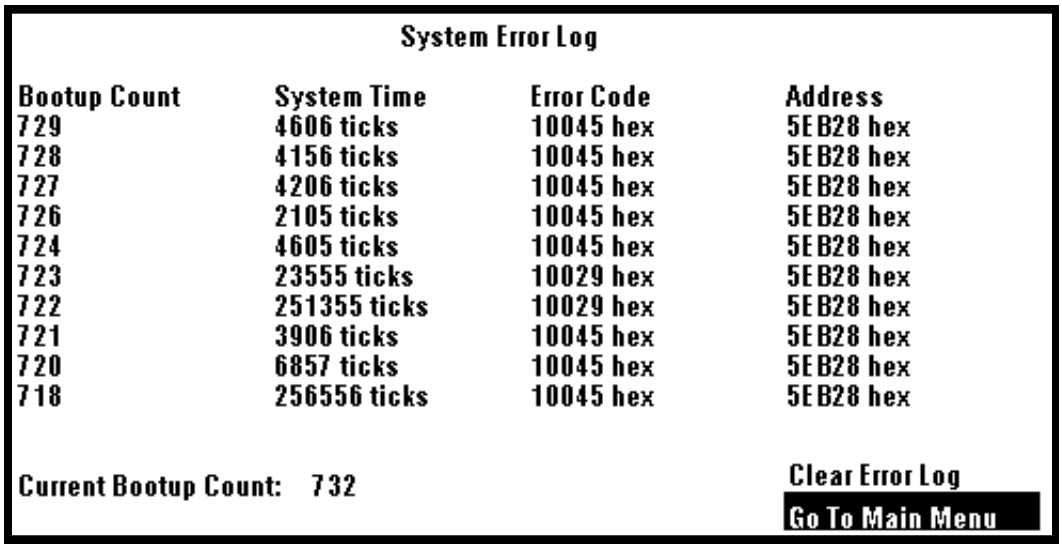
If the battery has been on charge for several hours and you get a "battery is not charged display:

Check the battery in-line cable fuse."

If the fuse is good, the battery is bad---replace it.

## System Error Log

The software displays the most current 10 errors that have been logged. The error code, address, and software revision are important pieces of information if technical support is required.




### Remarks

**Note:** The following Error Log table lists codes for those errors that pertain to service. Other codes will display from time to time, however, these are software informational codes only and should not be of concern to a service person.

The software clears the errors that have been logged when "Clear Error Log" is set so a new listing may be compiled.

## System Error Log Codes

The following table of error codes are numerical in order and may be referenced from the "System Error Log" menu displayed. Check the number on the menu and reference this table for description and service action. Actions are numbered in a logical action sequence. If action 1 fixes error, stop there, if action 3 fixes error return actions 1 and 2 to previous status.

| Error Code | Description of error logged | Service Action |
|---|---|---|
| 10023 | Defaults loaded to non-volatile memory EEPROM. | 1. If EEPROM or CPU board were replaced, clear error log and reboot.<br><br>2. EEPROM failure, replace EEPROMs<br><br>3. Replace CPU board |
| 10027 | Caused by high airway pressure above set Plimit | No Service Action required |
| 10029 | Minimum system monitoring caused by DPL switch tripping | Reboot the system, if problem continues refer to Section 4, Test Press. Limit Switch |
| 1002A | Minimum system monitoring caused by a low battery | Charge battery, if error continues replace battery |
| 1002B | Minimum system monitoring caused by incorrect flow valve feedback | Reboot the system, if problem continues refer to Section 4 Test Flow Valve |
| 1002C | Minimum system monitoring caused by incorrect GIV feedback | 1. Possible bad gas inlet valve<br><br>a. Disconnect the connector to GIV at J6. Measure ohms at approx. 25 ohms<br><br>b. If step a is unusually high or low replace GIV solenoid<br><br>2. Replace CPU board |
| 1002E | Minimum system monitoring caused by battery current A/D out of range. Battery current > 4 amperes | 1. Reboot the system, if problem continues replace the PSB (Power supply board)<br><br>2. Replace the CPU board<br><br>3. Replace battery |
| 1002F | Minimum system monitoring caused by battery voltage A/D out of range. Battery voltage > 16V. | 1. Reboot the system if problem continues, measure open circuit batt voltage<br><br>2. Replace the PSB<br><br>3. Replace the CPU board<br><br>4. Replace battery |
| 10030 | Minimum system monitoring caused by control setting change fail | Reboot the system, if problem continues replace the CPU board |

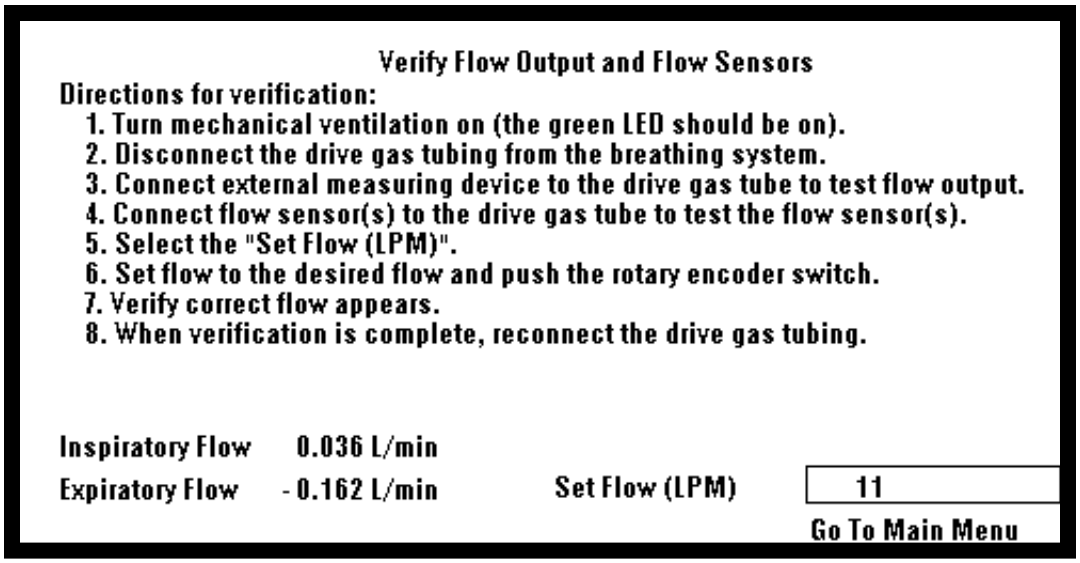
| Error Code | Description of error logged | Service Action |
|---|---|---|
| 10031 | Minimum system monitoring caused by flow sensor EEPROM failure | 1. Refer to Section 4 Display A/D Channels, Test Flow Sensors. Replace faulty flow sensors<br><br>2. Check cable connections at SIB and the SIB to 7900 cable<br><br>3. Replace the SIB<br><br>4. Replace the CPU board |
| 10032 | Minimum system monitoring caused by DCGO (French) | 1. System has DCGO in aux..position but language not set to French<br><br>2. Check Discrete I/O Signal menu for status<br><br>3. Check SIB cables<br><br>4. Replace CPU board |
| 10035 | Non-volatile memory EEPROM data out of range | Reboot the system, if problem continues replace the CPU board |
| 10036 | Non-volatile memory EEPROM region protected value error | Reboot the system, if problem continues replace the CPU board |
| 10038 | 1 of 3 safety relevant parameter areas has difference in SRC triplicate storage (external RAM problem) | Reboot the system, if problem continues replace the CPU board |
| 10039 | All 3 safety relevant parameter areas are different in SRC storage (external RAM problem) | Reboot the system, if problem continues replace the CPU board |
| 1003A | There are no more EEPROM areas to switch to (EEPROM problem) | Reboot the system, if problem continues replace the CPU board |
| 1003D | Minimum system monitoring caused by system parameter failure (external RAM problem) | Reboot the system, if problem continues replace the CPU board |
| 1003E | Minimum system monitoring caused by manifold pressure sensor failure | Reboot the system, if problem continues replace the CPU board |
| 10042 | The system clock has been reprogrammed (CPU timer problem) | Reboot the system, if problem continues replace the CPU board |
| 10045 | Sustained airway pressure holding for more than 10 seconds | No Service Action Required |
| 10046 | Minimum system shutdown low battery, less than 11.35V while system is running on battery | 1. Charge the battery<br><br>2. If the unit has been plugged in for 12 hours and the problem continues, replace battery |

| Error Code | Description of error logged | Service Action |
|---|---|---|
| 10047 | Minimum system shutdown SIB 15V test failed | 1. Reboot the system, if problem continues measure +15V±5% on J3 pin 1 to pin 2. If out of spec disconnect CPU and measure again.<br><br>2. If within spec continue.<br><br>3. Replace SIB<br><br>4. Replace PSB<br><br>5. Replace CPU board |
| 10048 | Minimum system shutdown 15V Local 10 VA test failed | 1. Replace PSB<br><br>2. Replace CPU board |
| 10049 | Minimum system shutdown display voltage test failed | 1. Reboot system, if problem continues measure EL display +14.5V (10-15V) volts at J3 pin 18 to pin 11.<br><br>2.If out of spec, disconnect Display board. Measure again. If within spec; replace Display board, continue<br><br>3. If still out of spec, disconnect CPU board. Measure again. If within spec, continue.<br><br>4. Replace CPU board. Measure again. If still out of spec, disconnect PSB, continue.<br><br>5. Replace PSB |
| 1004A | Minimum system shutdown A/D converter failure | Reboot the system, if problem continues replace the CPU board |
| 1004B | Minimum system shutdown CPU test failure | Reboot the system, if problem continues replace the CPU board |
| 1004C | Minimum system shutdown flash EPROM failure | Reboot the system, if problem continues replace the CPU board |
| 1004D | Minimum system shutdown external RAM failure | Reboot the system, if problem continues replace the CPU board |
| 1004E | Minimum system shutdown display RAM failure | Reboot the system, if problem continues replace the CPU board |
| 1004F | Minimum system shutdown software watchdog failure | Reboot the system, if problem continues replace the CPU board |
| 10050 | Minimum system shutdown sequential watchdog failure | Reboot the system, if problem continues replace the CPU board |
| 10051 | Minimum system shutdown CPU clock too fast | Reboot the system, if problem continues replace the CPU board |
| 10052 | Minimum system shutdown CPU clock too slow | Reboot the system, if problem continues replace the CPU board |

| Error Code | Description of error logged | Service Action |
|---|---|---|
| 10058 | Minimum system shutdown V_AUX test failed | 1. Reboot the system, if problem continues measure V_AUX. J3 pin 5 and pin 6. If out of spec disconnect CPU board, measure again. If within spec, continue. Range is +4.988 to +6.09 vdc.<br><br>2. Replace the CPU board<br><br>3. Replace PSB |
| 10059 | Minimum system shutdown external reference voltage failed | Reboot the system, if problem continues replace the CPU board |
| 1005A | Minimum system shutdown bootup memory failure | Reboot the system, if problem continues replace the CPU board |
| 2000D | A switch for EEPROM region was requested but there are no more areas to switch to (EEPROM problem) | Reboot the system, if problem continues replace the CPU board |

## Verify Flow

The software allows the user to set the flow from 0 (closed) to 120 LPM. The user can then verify that the flow output of the ventilator is correct and/or that the flow sensors read the correct output.


Verify Flow Output and Flow Sensors
Directions for verification:
1. Turn mechanical ventilation on (the green LED should be on).
2. Disconnect the drive gas tubing from the breathing system.
3. Connect external measuring device to the drive gas tube to test flow output.
4. Connect flow sensor(s) to the drive gas tube to test the flow sensor(s).
5. Select the "Set Flow (LPM)".
6. Set flow to the desired flow and push the rotary encoder switch.
7. Verify correct flow appears.
8. When verification is complete, reconnect the drive gas tubing.
Inspiratory Flow 0.036 L/min
Expiratory Flow - 0.162 L/min
Set Flow (LPM)
11
Go To Main Menu

**Remarks**

**Note**: Gas exiting through the bleed resistor must be accounted for or occluded when measuring flow valve output.

This service tool can be used for directly controlling the output of the flow valve. Gas from the 7900 flow valve exits from three separate areas; the two drive hoses and the bleed resistor. Independent measurements of flow valve output must capture all gas from these ports or provide for their occlusion. Be sure to remove all occlusion devices prior to returning the system to service.

This tool can provide flow for a check of the flow sensor's span, but only in an approximate sense. Variations between the flow sensor output and the flow valve setting can vary by as much as 25%. Use the Flow Sensor Operational Test as a more accurate measurement of flow sensor competency at lower flows.

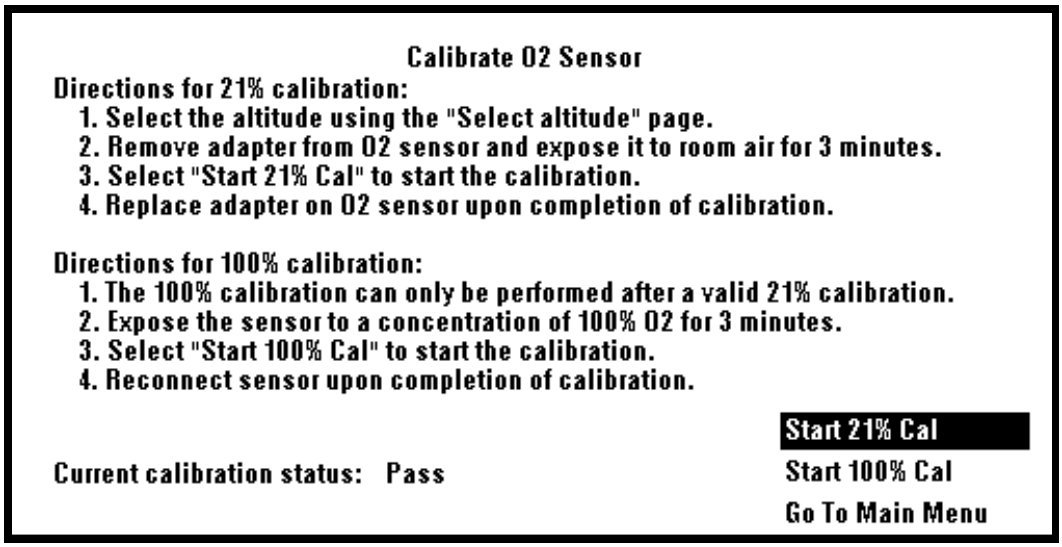
# 4.5. Calibrations

## Calibrate $O_2$ Sensor

See operation and maintenance manual.

The software calibrates the O2 sensor at a selected altitude, see "Select Altitude" menu. Set the appropriate altitude for the machine location. The software in the ventilator calibrates the O2 sensor by reading the A/D for the O2 sensor when the O2 sensor is exposed to room air (21% O2). If this A/D value is not within the tolerance the calibration fails. If the calibration passes, the A/D value at which the O2 sensor was calibrated is stored in the EEPROM.

The sensor must be calibrated at 21% O2 before calibration at 100% O2.


Calibrate O2 Sensor
Directions for 21% calibration:
1. Select the altitude using the "Select altitude" page.
2. Remove adapter from O2 sensor and expose it to room air for 3 minutes.
3. Select "Start 21% Cal" to start the calibration.
4. Replace adapter on O2 sensor upon completion of calibration.
Directions for 100% calibration:
1. The 100% calibration can only be performed after a valid 21% calibration.
2. Expose the sensor to a concentration of 100% O2 for 3 minutes.
3. Select "Start 100% Cal" to start the calibration.
4. Reconnect sensor upon completion of calibration.
Start 21% Cal
Current calibration status: Pass
Start 100% Cal
Go To Main Menu

**Remarks**

See operation and maintenance manual.

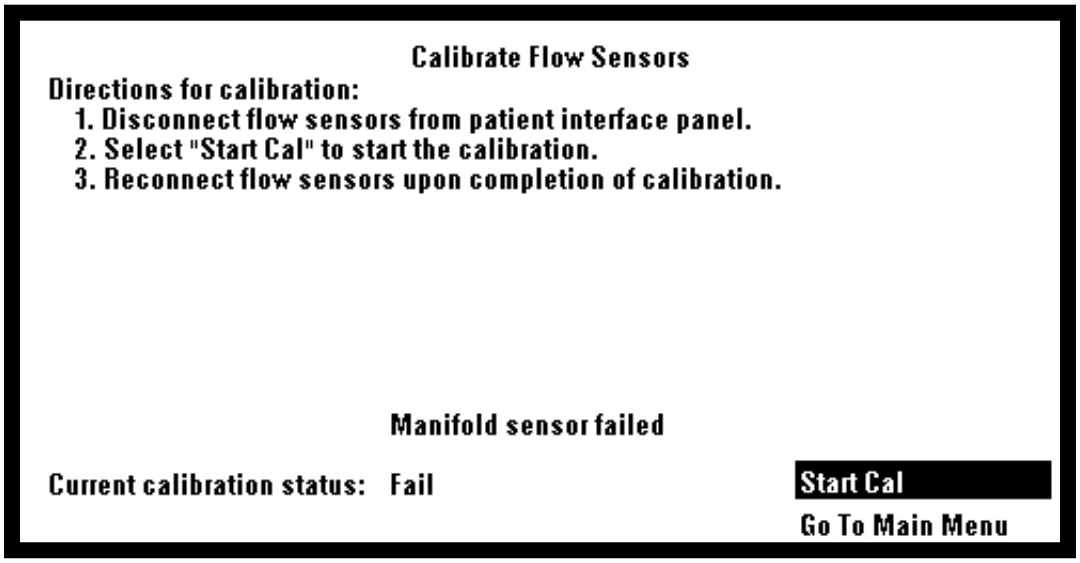
Remove the O2 sensor from the 15 mm adapter, ensure that the sensor is in an upright position with the cable connector at the top, and expose it to room air for approximately 3 minutes. The displayed reading should be 21% ± 2% to pass the calibration requirements. Place the sensor that passed the 21% test in the breathing system and expose it to 100% O2 for 3 minutes.

If the sensor passes, the A/D value at which it passed is stored in the EEPROM. If it displays readings higher or lower than required to pass, the sensor is bad. Replace it.

## Calibrate Flow Sensors

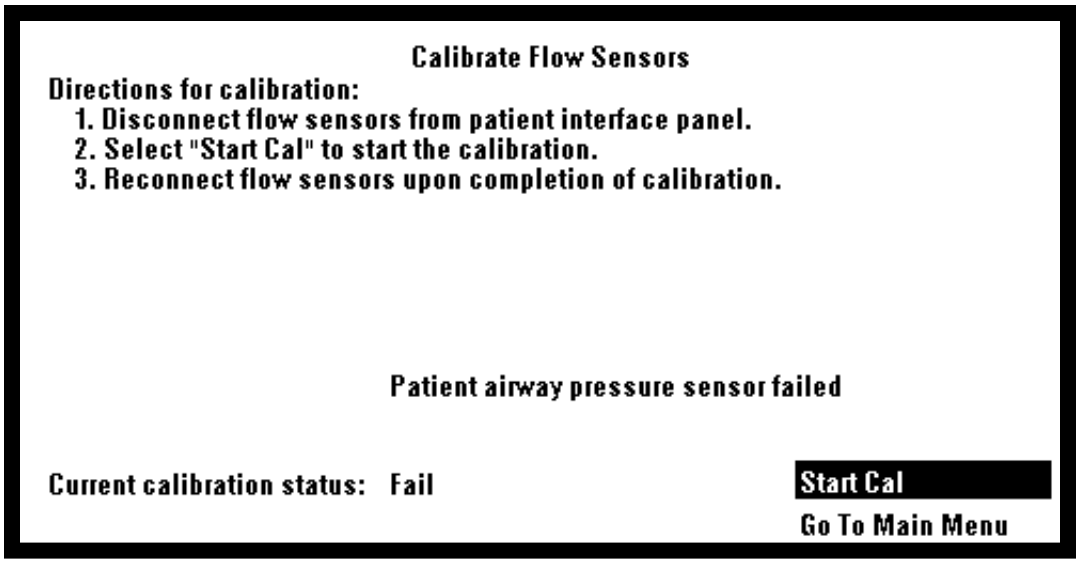
See operation and maintenance manual.

The software calibrates the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers for zero pressure offset voltage. It does so by reading the A/D for inspiratory flow, expiratory flow, airway pressure and manifold pressure when the flow sensors have been disconnected from the patient interface panel. If the A/D values are not within the correct tolerance the calibration fails. If the calibration passes, the A/D values at which the inspiratory flow, expiratory flow, airway pressure and manifold pressure transducers were calibrated at are stored in the EEPROM.


Calibrate Flow Sensors
Directions for calibration:
1. Disconnect flow sensors from patient interface panel.
2. Select "Start Cal" to start the calibration.
3. Reconnect flow sensors upon completion of calibration.
Manifold sensor failed
Current calibration status: Fail
Start Cal
Go To Main Menu

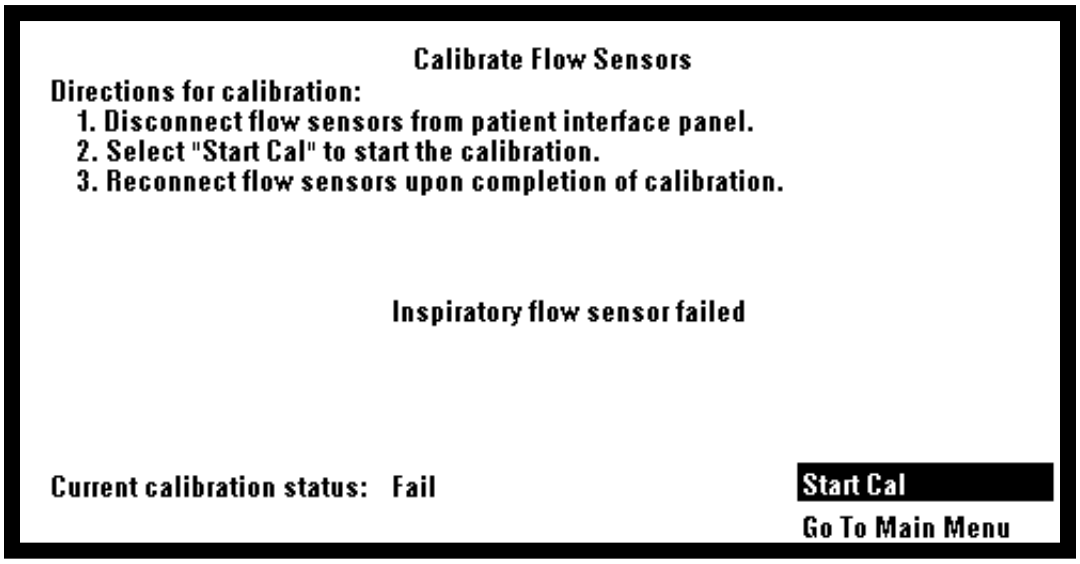
**Remarks**

Fail - indicates a problem with the microcontroller board, check for bad differential pressure transducer. Check the transducer outputs using the Display A/D menu. If the transducer is not zeroing, remove the exhalation valve from the manifold. If the transducer zeros, replace the flow valve. If not, replace the microcontroller board.


Calibrate Flow Sensors
Directions for calibration:
1. Disconnect flow sensors from patient interface panel.
2. Select "Start Cal" to start the calibration.
3. Reconnect flow sensors upon completion of calibration.
Patient airway pressure sensor failed
Current calibration status: Fail
Start Cal
Go To Main Menu

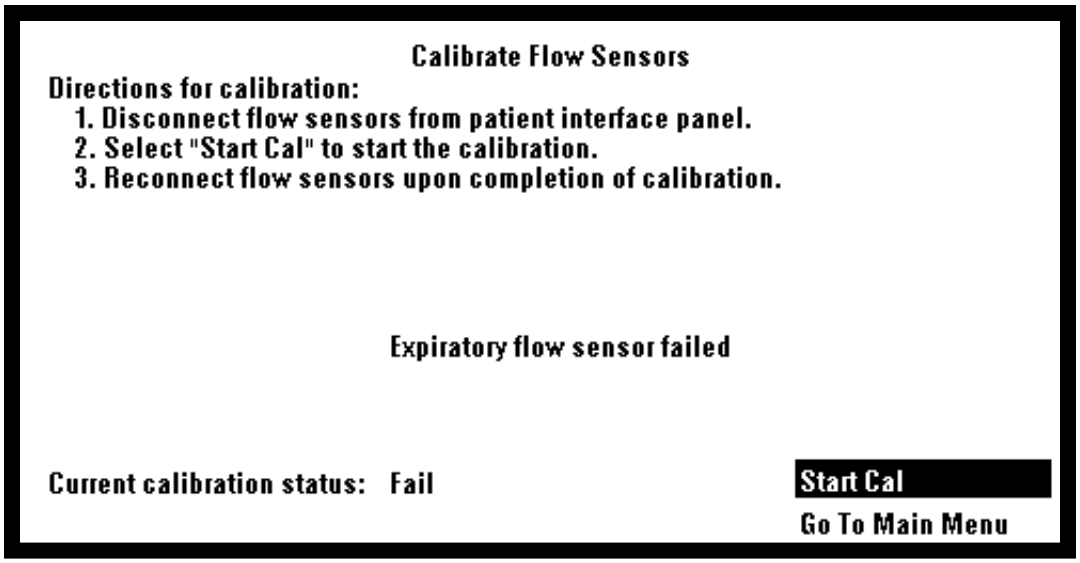
**Remarks**

Fail - indicates a problem with the SIB, check for bad differential pressure transducer. Check the transducer outputs using the Display A/D menu. Ensure that the flow sensors are disconnected from the interface panel. If the transducer is out of tolerance, replace the SIB assembly.


Calibrate Flow Sensors
Directions for calibration:
1. Disconnect flow sensors from patient interface panel.
2. Select "Start Cal" to start the calibration.
3. Reconnect flow sensors upon completion of calibration.
Inspiratory flow sensor failed
Current calibration status: Fail
Start Cal
Go To Main Menu

**Remarks**

Fail - indicates a problem with the SIB, check for bad differential pressure transducer. Check the transducer outputs using the Display A/D menu. Ensure that the flow sensors are disconnected from the interface panel. If the transducer is out of tolerance, replace the SIB assembly.

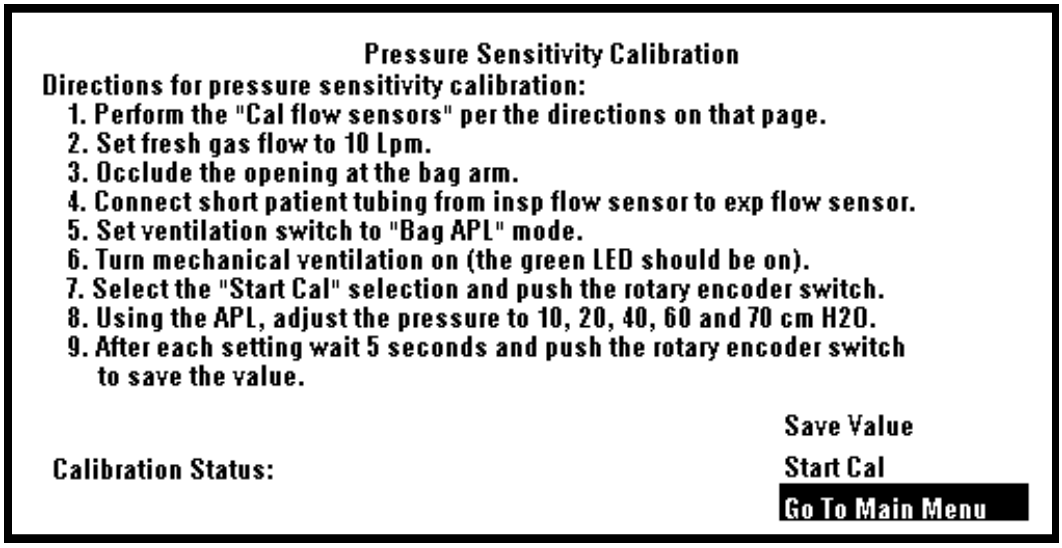

Calibrate Flow Sensors
Directions for calibration:
1. Disconnect flow sensors from patient interface panel.
2. Select "Start Cal" to start the calibration.
3. Reconnect flow sensors upon completion of calibration.
Expiratory flow sensor failed
Current calibration status: Fail
Start Cal
Go To Main Menu

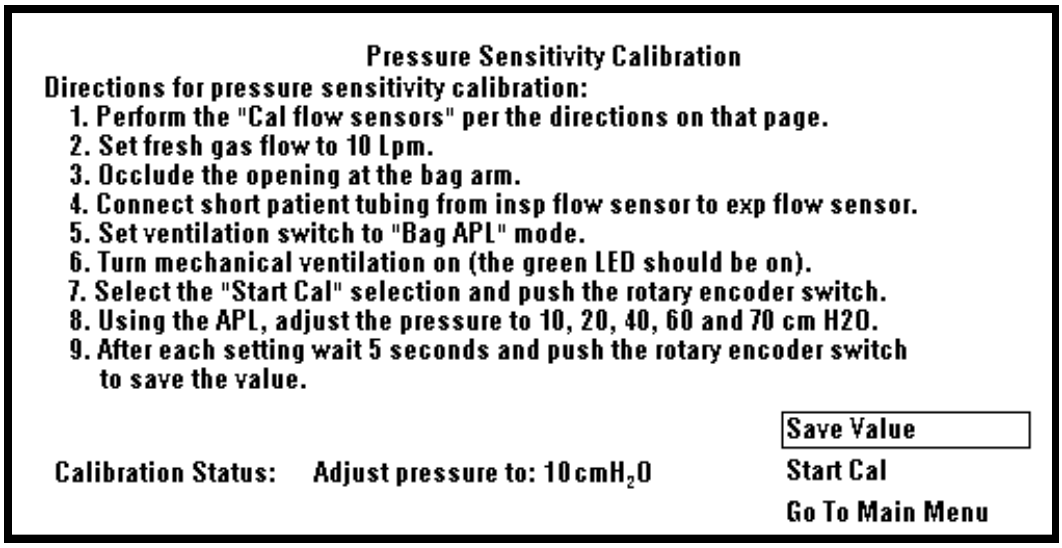
**Remarks**

Fail - indicates a problem with the SIB, check for bad differential pressure transducer. Check the transducer outputs using the Display A/D menu. Ensure that the flow sensors are disconnected from the interface panel. If the transducer is out of tolerance, replace the SIB assembly.

## Calibrate Pressure Sensitivity

The software prompts the user to perform the procedure to calibrate the pressure sensitivity (This pressure transducer calibration is to be performed if the SIB control module or microcontrol board is replaced). This calibration is not an automated calibration. It prompts the user to follow a set of procedural steps to perform the calibration. This calibration calculates the pressure sensitivity at 5 different pressures. It uses these five different pressure points along with the inspiratory flow and expiratory flow zero offsets to find the pressure sensitivity If the calculations for the pressure sensitivity are not within the correct tolerance, the calibration fails. If the calibration passed, the five pressure sensitivity points are stored in the EEPROM.


Pressure Sensitivity Calibration
Directions for pressure sensitivity calibration:
1. Perform the "Cal flow sensors" per the directions on that page.
2. Set fresh gas flow to 10 Lpm.
3. Occlude the opening at the bag arm.
4. Connect short patient tubing from insp flow sensor to exp flow sensor.
5. Set ventilation switch to "Bag APL" mode.
6. Turn mechanical ventilation on (the green LED should be on).
7. Select the "Start Cal" selection and push the rotary encoder switch.
8. Using the APL, adjust the pressure to 10, 20, 40, 60 and 70 cm H2O.
9. After each setting wait 5 seconds and push the rotary encoder switch to save the value.
Save Value
Calibration Status:
Start Cal
Go To Main Menu


Pressure Sensitivity Calibration
Directions for pressure sensitivity calibration:
1. Perform the "Cal flow sensors" per the directions on that page.
2. Set fresh gas flow to 10 Lpm.
3. Occlude the opening at the bag arm.
4. Connect short patient tubing from insp flow sensor to exp flow sensor.
5. Set ventilation switch to "Bag APL" mode.
6. Turn mechanical ventilation on (the green LED should be on).
7. Select the "Start Cal" selection and push the rotary encoder switch.
8. Using the APL, adjust the pressure to 10, 20, 40, 60 and 70 cm H2O.
9. After each setting wait 5 seconds and push the rotary encoder switch to save the value.
Save Value
Calibration Status: Adjust pressure to: 10 cmH2O
Start Cal
Go To Main Menu

**Pressure Sensitivity Fail**

1. Select "Display A/D Channels" from the main service menu.
   Set Fresh gas flow to 2 Lpm.
   Open the APL valve (0 cm $H_2O$).
   Place Bag to Vent switch in the Bag/APL position.
   Connect a short tube between the inspiratory and expiratory flow sensors.

The airway pressure, inspiratory flow and expiratory flow on the ventilator display should read near zero (between +.5 and -.5 Lpm flows).

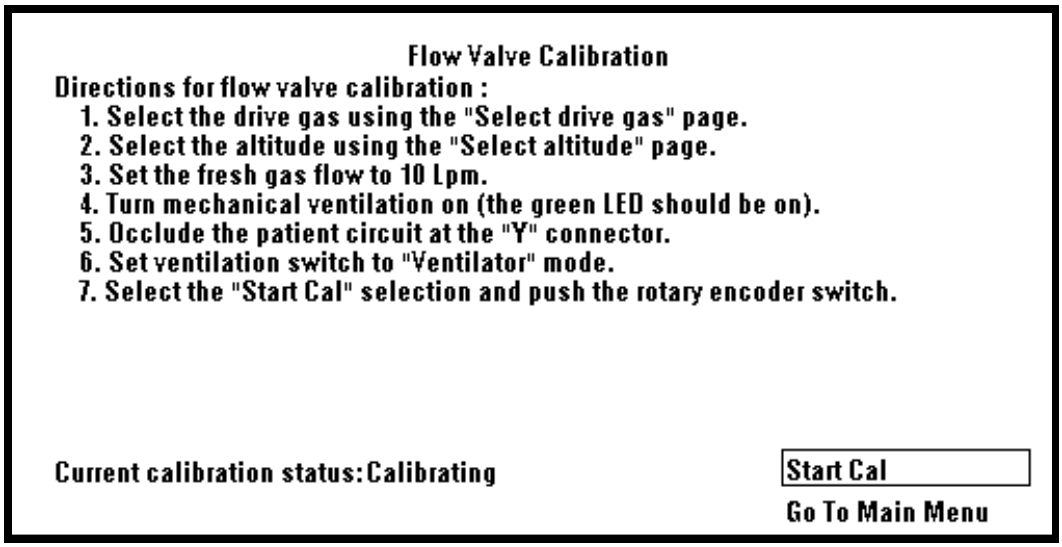
2. Occlude the GMS (or MAS) bag port. Adjust the APL to read 10 cm$H_2O$ on the gauge. The flow may jump briefly, but should stabilize to read between +.5 and -.5 Lpm. Very gently push the tubes coming from the flow sensors slightly in all directions. Observe to see if the flow measurements jump.

**Caution** ⚠ **If either sensor reads more than 2 Lpm, STOP. This indicates a possible leak in the flow sensor pneumatic circuit. Skip steps 3 and 4, go directly to step 5. If the pressure is increased further, the SIB may be damaged.**

3. Adjust the APL to read 20 cm$H_2O$ on the gauge. The flows may jump briefly, but should stabilize to read between +.5 and -.5 Lpm.
4. Adjust the APL to read 40 cm$H_2O$ on the gauge. The flows may jump briefly, but should stabilize to read between +.5 and -.5 Lpm.
5. If the flow measurements on the ADC page stay near zero, the flow sensors are good. If either sensor indicates a flow where there is none, there may be a leak. To troubleshoot, reduce the circuit pressure back to zero. Reverse the flow sensor connections at the SIB interface panel and repeat the above tests.
6. If the problem follows the sensor, discard the sensor. It has a leak.
7. If the problem stays with the same side of the circuit, it is likely the leak is in the tubing under the SE table top, not with the sensor.

## Calibrate Flow Valve

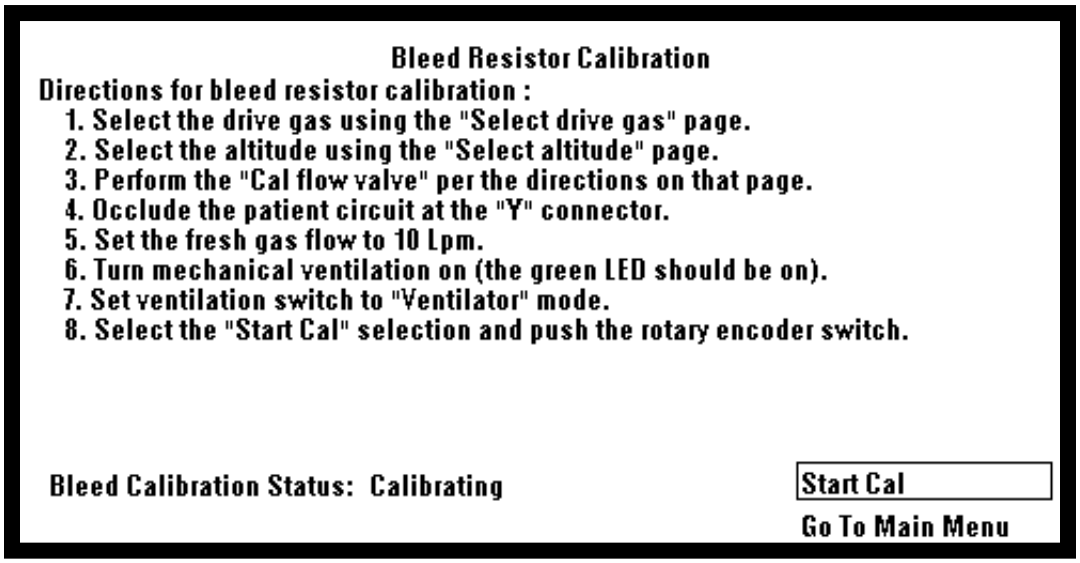
The software prompts the user to perform the procedural steps to calibrate the flow valve. This is an automated calibration. It gradually opens the flow valve and monitors the manifold pressure. When the manifold pressure reaches 1.9 to 2.0 $cmH_2O$ the value at which the flow valve has been opened is saved. The flow valve is then closed. The value at which the flow valve was opened to is then checked to make sure it is within the correct tolerance. If it is not, the calibration fails. If the calibration passes, the flow valve calibration point is stored in the EEPROM.

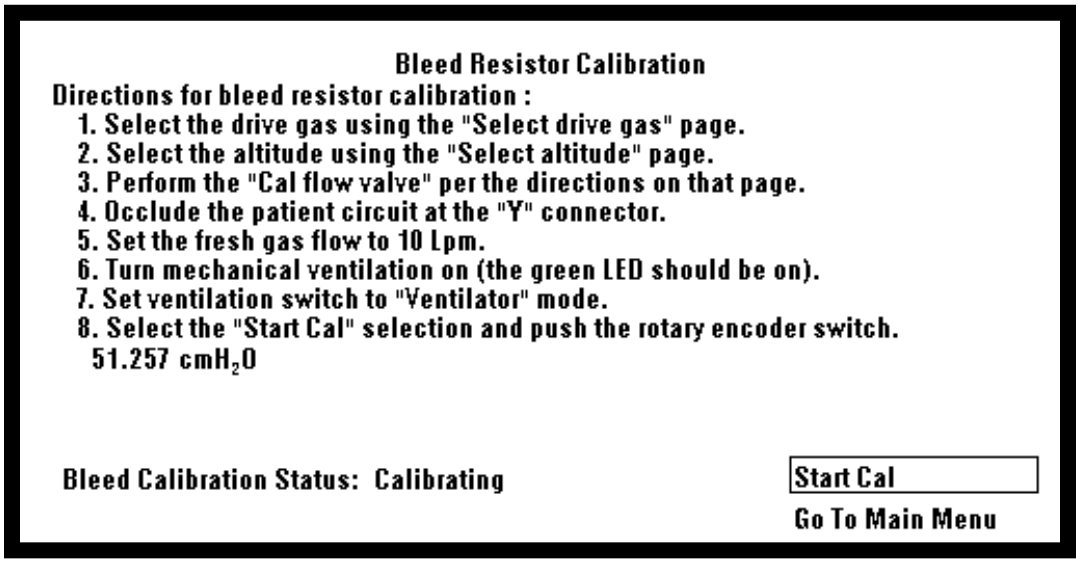

Flow Valve Calibration
Directions for flow valve calibration :
1. Select the drive gas using the "Select drive gas" page.
2. Select the altitude using the "Select altitude" page.
3. Set the fresh gas flow to 10 Lpm.
4. Turn mechanical ventilation on (the green LED should be on).
5. Occlude the patient circuit at the "Y" connector.
6. Set ventilation switch to "Ventilator" mode.
7. Select the "Start Cal" selection and push the rotary encoder switch.
Current calibration status: Calibrating
Start Cal
Go To Main Menu

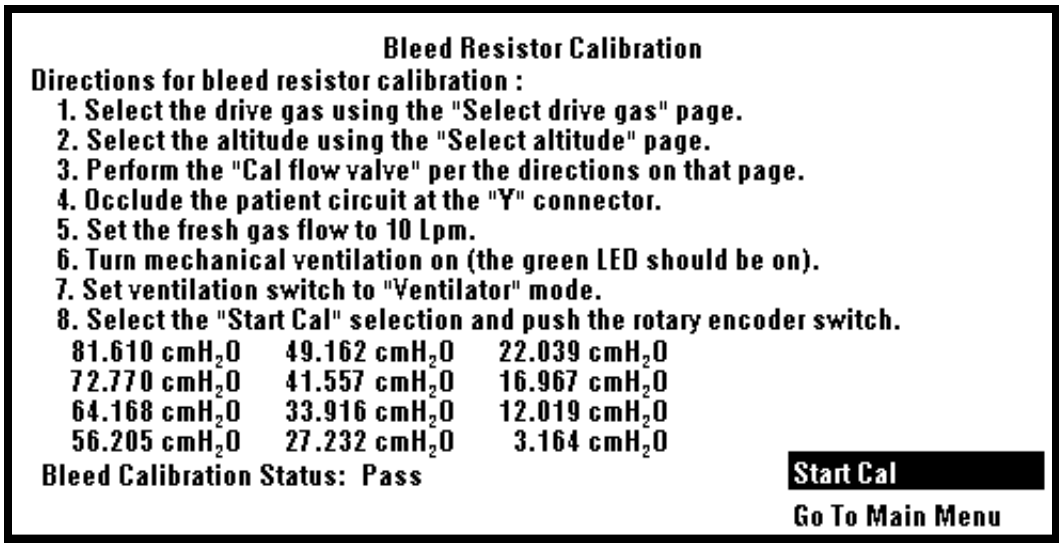
**Remarks**: Check that the bag/vent selection switch is in the vent position. If the flow valve calibration test fails immediately, the most likely fault is a bad manifold transducer. It can also be a bad regulator or the regulator is out of calibration. Another cause could be a bad flow valve.

## Calibrate Bleed Resistor

The software calibrates the bleed resistor using the following procedure steps (besides the setup procedure this calibration is completely automated). First the software finds the value at which to set the flow valve to get a manifold pressure of 91-92 $cmH_2O$. Once it finds this starting point value the automated calibration begins. Values shown here are for example only and are not necessarily typical.


Bleed Resistor Calibration
Directions for bleed resistor calibration :
1. Select the drive gas using the "Select drive gas" page.
2. Select the altitude using the "Select altitude" page.
3. Perform the "Cal flow valve" per the directions on that page.
4. Occlude the patient circuit at the "Y" connector.
5. Set the fresh gas flow to 10 Lpm.
6. Turn mechanical ventilation on (the green LED should be on).
7. Set ventilation switch to "Ventilator" mode.
8. Select the "Start Cal" selection and push the rotary encoder switch.
Bleed Calibration Status: Calibrating
Start Cal
Go To Main Menu


Bleed Resistor Calibration
Directions for bleed resistor calibration :
1. Select the drive gas using the "Select drive gas" page.
2. Select the altitude using the "Select altitude" page.
3. Perform the "Cal flow valve" per the directions on that page.
4. Occlude the patient circuit at the "Y" connector.
5. Set the fresh gas flow to 10 Lpm.
6. Turn mechanical ventilation on (the green LED should be on).
7. Set ventilation switch to "Ventilator" mode.
8. Select the "Start Cal" selection and push the rotary encoder switch.
51.257 cmH2O
Bleed Calibration Status: Calibrating
Start Cal
Go To Main Menu


Bleed Resistor Calibration
Directions for bleed resistor calibration :
1. Select the drive gas using the "Select drive gas" page.
2. Select the altitude using the "Select altitude" page.
3. Perform the "Cal flow valve" per the directions on that page.
4. Occlude the patient circuit at the "Y" connector.
5. Set the fresh gas flow to 10 Lpm.
6. Turn mechanical ventilation on (the green LED should be on).
7. Set ventilation switch to "Ventilator" mode.
8. Select the "Start Cal" selection and push the rotary encoder switch.
81.610 cmH2O 49.162 cmH2O 22.039 cmH2O
72.770 cmH2O 41.557 cmH2O 16.967 cmH2O
64.168 cmH2O 33.916 cmH2O 12.019 cmH2O
56.205 cmH2O 27.232 cmH2O 3.164 cmH2O
Bleed Calibration Status: Pass
Start Cal
Go To Main Menu

**Remarks**: If the bleed resistor calibration test fails, check altitude and drive gas settings. Ensure that the breathing circuit gas is exhausting out the scavenging port during the test. A negative finding indicates a massive circuit leak. Check for proper regulator pressure calibration. Ensure that the Flow Valve Cal test was conducted properly. Otherwise, failure indicates a calibration problem with the flow valve.

**Remarks**

The calibration is performed as follows:

1. Open the flow valve to the starting point that was found (where manifold pressure is 91-92 cm $H_2O$).
2. Wait for the flow to stabilize.
3. Once the flow stabilized, set the flow to 12 L/min.
4. Wait for the flow to stabilize.
5. Perform steps 1-6 replacing step 3 with 11 L/min., 10 L/min., 9 L/min. 1 L/min..

Therefore, there are 12 points that are calculated for the bleed resistor calibration. Calibration points may be greater than the listed cm $H_2O$, but if any one of these points is less than the cm$H_2O$ listed below, calibration fails. If the calibration passes, the calculated bleed resistor calibration points are stored in EEPROM.

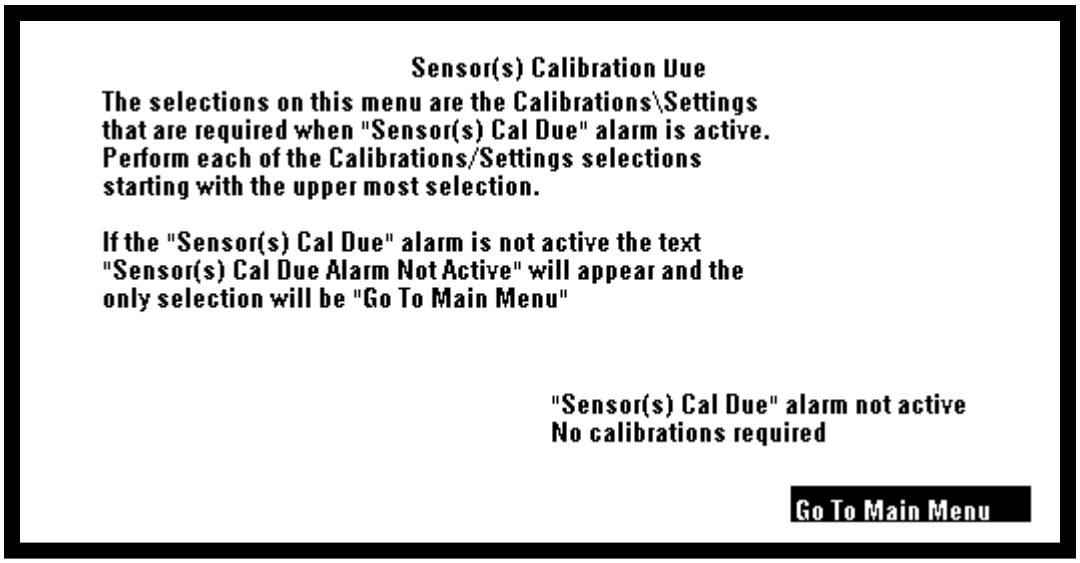
| |
|---|
| 67 cm $H_20$ |
| 59 cm $H_20$ |
| 52 cm $H_20$ |
| 45 cm $H_20$ |
| 38 cm $H_20$ |
| 30 cm $H_20$ |
| 24 cm $H_20$ |
| 18 cm $H_20$ |
| 12 cm $H_20$ |
| 7 cm $H_20$ |
| -5 cm $H_20$ |
| -5 cm $H_20$ |

## Sensor(s) Cal Due

This menu displays which sensors or setting must be performed when the "Sensors Cal Due" alarm appears in normal operation. After the cal/setting is properly completed, the text for that cal/setting will be removed.

If the "Sensor(s) Cal Due" alarm is not active, the menu displays the text:

"Sensor(s) Cal Due" alarm not active
No calibrations required


Sensor(s) Calibration Due
The selections on this menu are the Calibrations\Settings
that are required when "Sensor(s) Cal Due" alarm is active.
Perform each of the Calibrations/Settings selections
starting with the upper most selection.
If the "Sensor(s) Cal Due" alarm is not active the text
"Sensor(s) Cal Due Alarm Not Active" will appear and the
only selection will be "Go To Main Menu"
"Sensor(s) Cal Due" alarm not active
No calibrations required
Go To Main Menu

# 4.6. User Settings

These setting are for the convenience of the service person so they can make changes without having to go back to the main operating menus

## Select Altitude

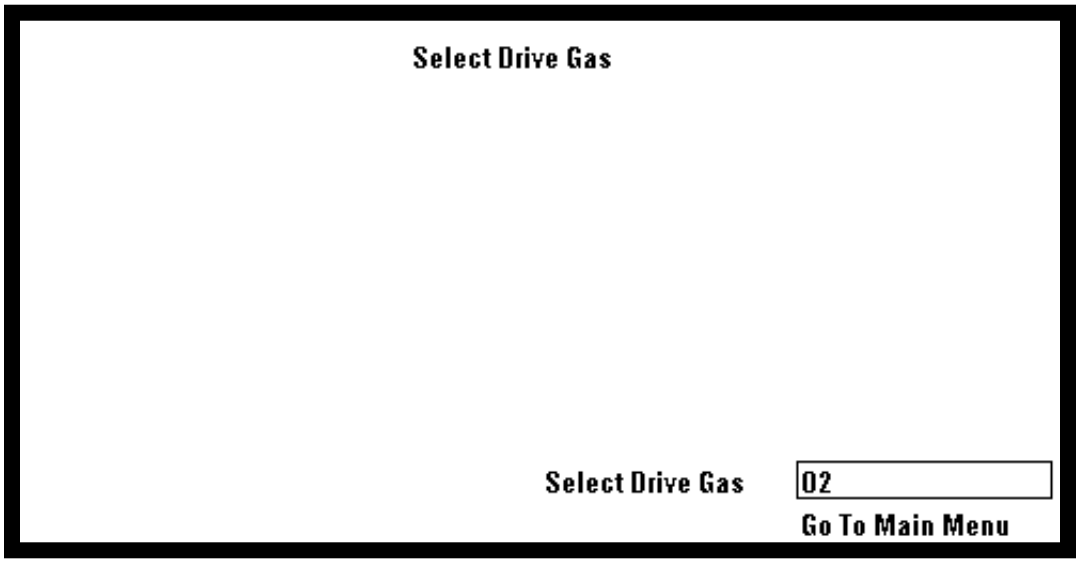
This provides the user with the means to select the altitude setting.

**Displays**

## Select Drive Gas

This provides the user with the means to select the drive gas.

**Displays**

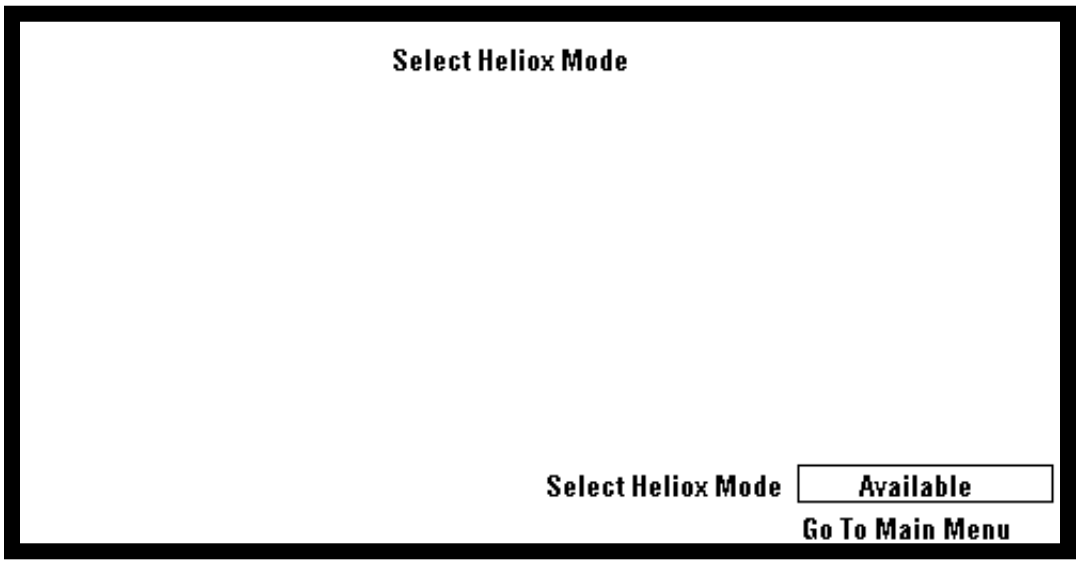


## Adjust Brightness

This provides the user with the means to select the display brightness.

## Select Heliox Mode

This provides the user with the means to select the Heliox mode with systems having ANSI gas systems with Heliox flow tubes installed. Set "Select Heliox Mode" to Available to allow the user to turn Heliox mode on or off during the normal operations mode. Set "Select Heliox Mode" to Not Available to prevent the user from turning Heliox mode on during normal operation.



## Exit Service Mode

Provides the means to exit the service mode via a hardware reset.

Allows the service person to return to the main operating waveform display and operating menu.

## 4.7. Troubleshooting Guides

Some ventilator problems may not generate any ventilator messages, even though the ventilator may not be functioning correctly.

Operational alarm messages are found in the Operation and Maintenance manual. Actions are numbered in a logical action sequence. If action 1 fixes error, stop there, if action 3 fixes error return actions 1 and 2 to previous status.

### Troubleshooting Mechanical/Electrical

| Symptom | Probable Cause | Action |
|---|---|---|
| System on/AC LED on, no display | 1. 50 position cable, membrane to power supply board<br>2. 18 position cable, power supply board to CPU board<br>3. EL display<br>4. CPU board<br>5. Power supply board | 1. Check cable connection<br>2. Check cable connection<br>3. Replace EL display<br>4. Replace CPU board<br>5. Replace power supply board |
| AC LED not on | 1. Power cord<br>2. AC power<br>3. Power cord fuses<br>4. 50 position cable, front panel to microcontroller board<br>5. Power supply board<br>6. Membrane switch LED | 1. Is the cord plugged in?<br>2. Is the power outlet o.k.?<br>3. Check power cord fuses in the power module<br>4. Check cable connection<br>5. Verify output voltages of power supply. Replace power supply board<br>6. Replace front panel keyboard |
| Alarms display, but no audible | 1. Audio set too low<br>2. Speaker cable<br>3. Speaker<br>4. CPU board | 1. Adjust audio from menu<br>2. Ensure cable is plugged in<br>3. Replace speaker<br>4. Replace CPU board |
| Bellows does not expand or tends to collapse during ventilation. | 1. Leak in the breathing circuit.<br>2. Bellows not installed properly.<br>3. Tear or leak in bellows.<br>4. Insufficient fresh gas flow.<br>5. Improperly functioning ABA diaphragm and seat assembly. | 1. Check breathing circuit and absorber for leaks.<br>2. Check the bellows to base attachment.<br>3. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions.<br>4. Check that settings on flowmeters are adequate.<br>5. Check diaphragm and seat assembly. |

| Symptom | Probable Cause | Action |
|---|---|---|
| Bellows distended and/or slips off base. | 1. Bellows retention problem.<br>2. Bellows assembly exhaust restricted.<br>3. Bellows assembly pressure relief valve problem. | 1. Check bellows.<br>2. Check the waste gas scavenging system for high vacuum or blockage.<br>3. Control port plugged or drive gas inlet hose blocked. |
| Continuous flow of supply gas before machine is turned ON. | 1. External hose leak.<br>2. GIV leak. | 1. Check hose.<br>2. Check GIV solenoid.<br>3. Repair GIV |
| Bellows does not descend during inspiration. | 1. Bag/APL-Vent selector in Bag/APL position.<br>2. Drive gas hose disconnected or leaking. | 1. Place the Bag/APL-Vent selector in the Vent position.<br>2. Reconnect drive gas hose or check for leaks. |
| Alarms sound without apparent cause and cannot be silenced. | 1. Microprocessor failure. | 1. Replace microcontrol board. |
| Ventilator will not turn on when remote on/off switch is turned on and AC LED is on | 1. 50 position cable, external cable SIB to 7900<br>2. Remote on/off switch cable<br>3. Remote on/off switch<br>4. Power supply board | 1. Ensure cable is plugged in properly at 7900 and SIB<br>2. Ensure cable is plugged in properly at switch and SIB<br>3. Replace switch<br>4. Replace power supply board |
| Settings do not meet specifications. | 1. Out of calibration. | 1. Calibrate. |
| Erratic pressure waveform<br><br>Slow exhalation pressure release | 1. Slight to moderate valve leakage<br>2. O-Ring Seal, Housing to Main Manifold<br>3. Alignment of seat and seal after assembly<br>4. Loose mounting screws | 1. Check operation of drive gas check Valve<br>2. Replace drive gas check valve |

IMPORTANT If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two (2) seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous

beeping audio alarm can be silenced only by turning the ventilator or anesthesia machine, as applicable, power switch OFF and after five seconds back ON.

**WARNING:** ⚠ **Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternated ventilator/anesthesia system can be used.**

## Troubleshooting by Alarm Messages

| Alarm Message/Symptom | Condition/Probable Cause | Service Action |
|---|---|---|
| 12 hour test | 12 continuous hours since last OFF state test | Cycle mechanical ventilation ON and OFF |
| Inspiratory Overshoot | PAW is greater than Pinspired threshold | Change threshold |
| Pinspired not achieved | Pmax does not reach a Pinspired threshold | 1. User may still have control of actual Pinspired (Conditions or combination of settings may prevent ventilator from achieving settings) Refer to Pressure Sensitivity CAL Fail listed in Section 4. |
| PEEP Not Achieved | Pmin - PEEP is not within a specific window | 1. Check tubing connections Rate and/or I:E Ratio may prevent ventilator from reaching desired PEEP level |
| Heliox Mode is ON | Heliox Mode selected | Select only if using $HeO_2$ gas mixture |
| $V_T$ Not Achieved | $V_{TI}$ less than $V_T$-threshold | Preset tidal volume not achieved Operator may still influence tidal volume with settings Refer to Pressure Sensitivity CAL Fail listed in Section 4. |
| Bellows Empty | Manifold pressure greater than airway pressure plus threshold | 1. Check fresh gas flow<br>2. Check and restore breathing circuit volume, breath cannot be delivered until bellows volume is restored |
| Check $O_2$ sensor | $O_2$ less than threshold (8% $O_2$) | 1. Calibrate $O_2$ sensor<br>2. Replace $O_2$ sensor |
| Circuit Auxiliary | Use of auxiliary circuit in DCGO | 1. Check dual common gas outlet<br>2. Check that auxiliary circuit is in use |

| Alarm Message/Symptom | Condition/Probable Cause | Service Action |
|---|---|---|
| Inspiratory flow sensor Fail<br>Expiratory flow sensor Fail | EEPROM cal data read failure (using default cal data | Remove flow sensor from breathing circuit.<br>Disconnect from patient interface panel and reconnect sensor. If error message goes away, sensor OK. If error message reappears, replace bad flow sensor |
| Insp. $V_T/V_{TE}$ volume Mismatch | $V_{TE}$ greater than $V_{TI}$ (Circle) or $V_{TI}$ greater than V delivered (Bain or Circle) | 1. Check system tubing for leakage. Refer to Pressure Sensitivity CAL Fail in Section 4.<br>2. Check the flow sensor<br>3. Replace the flow sensor |
| 1. No Insp Flow Sensor<br>2. No Exp Flow Sensor<br>3. Inspiratory Reverse Flow<br>4. Expiratory Reverse Flow<br>5. Check Flow Sensors | 1. No inspiratory flow sensor connected<br>2. No expiratory flow sensor connected<br>3. Negative flow on inspiratory flow sensor during inspiration<br>4. Negative flow on expiratory flow sensor<br>5. Incorrect connection, 0 flow on Insp sensor during inspiration, or 0 flow on Exp sensor in expiration after seeing flow in inspiration | 1. Examine check valves, free breathing valve and MOBO<br>2. Check flow sensor locations and tubing connections<br>3. Check breathing circuit configuration |
| $O_2$ calibration error | $O_2$ not equal to set $O_2$ f± 1%<br>$O_2$ greater than 110% | Calibrate $O_2$ sensor |
| On Battery | Status line indicates "on battery", or battery current test greater than 300 mA | 1. Is AC LED off?<br>2. Check system power cord and fuses<br>3. Check AC wall power, if o.k replace battery - replace CPU<br>Be aware of a 30 min. max. of batt. operation |
| Sans Gas Frais | Patient breathing in DCGO | Operator has attempted to turn on the ventilator with the dual common gas outlet in the auxiliary position |
| A/D Converter Failure<br>Minimum System Shutdown | ADC time out, monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |
| Bootup Memory Failure<br>Minimum System Shutdown | Bootup memory CRC failure, monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |

| Alarm Message/ Symptom | Condition/Probable Cause | Service Action |
|---|---|---|
| Control setting input has failed<br><br>Minimum system monitoring | Internal software error has occurred in a control setting change initiated by the user. Monitoring still available | Reboot ventilator, if problem continues replace CPU board |
| CPU Failure<br><br>Minimum System Shutdown | ALU, register,... test failure. Monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |
| CPU Internal Error<br><br>Minimum System Shutdown | Internal bus error. Monitoring is not functioning or unreliable | Reboot ventilator, if problem continues replace CPU board |
| Display Voltage Out-of-Range<br><br>Minimum System Shutdown | Voltage out-of-range. Monitoring is not functioning or unreliable | 1. Reboot ventilator, if problem continues, measure EL display +14.5V (10-15V) volts at J3 pin 18 to pin 11.<br><br>2.If out of spec, disconnect Display board. Measure again. If within spec; replace Display board, continue<br><br>3. If still out of spec, disconnect CPU board. Measure again. If within spec, continue.<br><br>4. Replace CPU board. Measure again. If still out of spec, disconnect PSB, continue.<br><br>5. Replace PSB |
| Flow Valve Failure<br><br>Minimum System Monitoring | Incorrect feedback. Monitoring is still available | 1. Reboot ventilator, if problem persists, continue:<br><br>2. Disconnect the connector to flow valve at J7. Refer to service mode Test Flow Valve diagnostic in section 4. |
| Gas Inlet Valve Circuit Failure<br><br>Minimum System Monitoring | Incorrect feedback. Monitoring still available | 1. Reboot ventilator, if problem persists, continues<br>2. Disconnect the connector to GIV at J6. Refer to service mode, Test GIV, Section 4. |
| Internal Ventilator Clock Too Fast<br><br>Minimum System Shutdown | Clock frequency greater than 110% of expected value. Monitoring is not functioning or unreliable | Reboot ventilator, if problem continues replace CPU board |
| Internal Ventilator Clock Too Slow<br><br>Minimum System Shutdown | Clock frequency less than 90% of expected value. Monitoring is not functioning or unreliable | Reboot ventilator, if problem continues replace CPU board |
| Logical Watchdog Failure<br><br>Minimum System Shutdown | Time-out or incorrect code executed. Monitoring is not functioning or unreliable | Reboot ventilator, if problem continues replace CPU board |

| Alarm Message/Symptom | Condition/Probable Cause | Service Action |
|---|---|---|
| Memory (EEPROM) Failure | 1. If EEPROM or CPU board was replaced, reboot the ventilator<br><br>2. Read/write failure, CRC failure<br><br>3. Default values will be used at power up | Reboot ventilator, if problem continues replace CPU board |
| Memory (flash) Failure<br><br>Minimum System Shutdown | CRC failure. Monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |
| Memory (RAM) Failure<br><br>Minimum System Shutdown | Walking pattern test failure. Monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |
| Memory (video) Failure<br><br>Minimum System Shutdown | Redundant storage test failure. Monitoring is not functioning or it is unreliable | Reboot ventilator, if problem continues replace CPU board |
| Auxiliary gas outlet | DCGO switch is in auxiliary position and language is not French | Check switch and language settings |
| No Battery | Battery voltage less than 7 V while running on machine elect power | 1. Check inline batt fuse<br><br>2. Measure batt volts 12.5 but <16V<br><br>3. Replace battery |
| Low Battery Charge | Voltage less than 12.5V while running on machine elect power | 1. This message should disappear after charging for 12 hours.<br><br>2. Measure batt volts 12.5 but <16V.<br><br>3. If not the battery may be defective and need replacement |
| Low Battery Minimum System Monitoring | Battery voltage less than 11.35V while running on battery | 1. Charge battery.<br><br>2. Measure batt volts 12.5 but <16V. If error message doesn't clear, replace battery |
| System Shutdown Minimum System Shutdown | Battery voltage less than 10.9V while running on battery | 1. Charge battery.<br><br>2. If error message doesn't clear, replace battery |
| Battery Voltage out of range<br><br>Battery current out of range | Battery Voltage > 16V<br><br>Battery current > 4 amps<br><br>System is unable to run on backup batt. | 1. Reboot ventilator, if problem continues replace PSB board<br><br>2. Replace the CPU board |

| Alarm Message/Symptom | Condition/Probable Cause | Service Action |
|---|---|---|
| +15V analog Out-of-Range<br><br>Minimum System Shut-down | + 15V out of range | 1. Reboot ventilator, if problem continues measure +15V±.75V at J3 pin 1 and pin 2. If out of spec, disconnect CPU, measure again. If within spec continue<br><br>2. Replace CPU board<br><br>3. Replace the PSB |
| +15V SIB Out-of-Range<br>Minimum System Shut-down | +15V out of range | 1. Reboot ventilator, if problem continues measure +15V at J3 pin 1 and pin 2. If out of spec<br><br>2. Replace PSB board<br><br>3. Replace the CPU board<br><br>4. Replace SIB |
| Manifold pressure sensor failure<br><br>Minimum system monitor-ing | Drive pressure limit switch engages and manifold pressure is not greater than 80 cmH2O or bootup calibration of manifold failed. | Reboot ventilator, if problem con-tinues replace CPU board |
| Pressure control PEEP disabled | Manifold pressure < airway pres-sure | Ventilate in volume mode only (without PEEP. Ventilator needs service). |
| Sequential Watchdog Failure<br><br>Minimum System Shut-down | Time-out or state failure. Moni-toring is not functioning or unreli-able. | Reboot ventilator, if problem con-tinues replace CPU board |
| Vaux_ref out-of range<br>Minimum system shutdown | +5.8 V out of range<br><br>Range is +4.988 Vdc to +6.09 Vdc | 1. Reboot ventilator, if problem continues measure +5.8 V at J3, pin 5 and pin 6. If out of spec dis-connect CPU. Measure again. If within spec, continue<br><br>2. Replace the CPU board<br><br>3. Replace PSB |
| Vext_ref out- of-range<br>Minimum system shutdown | +1.225 V out of range | Reboot ventilator, if problem con-tinues replace CPU board |

**WARNING:** ⚠ **Post-Service Checkout is required after you complete this section. You must perform section " 3/Post-Service Checkout" after performing any maintenance, service or repair. Failure to do so may result in patient injury.**

# 5/Maintenance

## 5.1. Maintenance Schedule

**WARNING: ⚠ Do not perform testing or maintenance on this instrument while it is being used to ventilate a patient, possible injury may result.**

**WARNING: ⚠ Items may be contaminated due to infectious patients. Wear sterile rubber gloves. Contamination can spread to yourself and others.**

### Maintenance

Perform User Maintenance from O&M Manual

Perform Test and Maintenance procedures from this Service Manual

### Yearly Maintenance Checks

In addition to the items specified in the O&M --

1. Run the flow sensor calibration test
2. Run the Pressure Sensitivity Cal menu
3. Verify regulator pressure at 25 psig. ± 0.2 psi at 15 L/min. of flow. Set the valve to the 15 L/min. point using the "Verify Flow" Menu; adjust as necessary
4. Run the Flow Valve Cal menu
5. Run the Cal Bleed Resistor menu
6. Run Test Flow Valve menu
7. Run Test Gas Inlet Valve menu
8. Run Test Pressure Limit Switch menu
9. Remove the Exhalation Manifold. Mechanically cycle the MOBO Valve weights, see section 6, figure 6-32
10. Inspect ventilator tubing, bellows, exhalation valve elastomers and supply gas filter

### Two Year Maintenance

Replace:

Internal Battery - Dispose of battery according to local codes

Free Breathing Valve

Free Breathing Valve Seat O-ring

During a maintenance visit, user level maintenance must be performed in addition to this maintenance. User level maintenance can be found in the 7900 Ventilator, Operation and Maintenance manual.

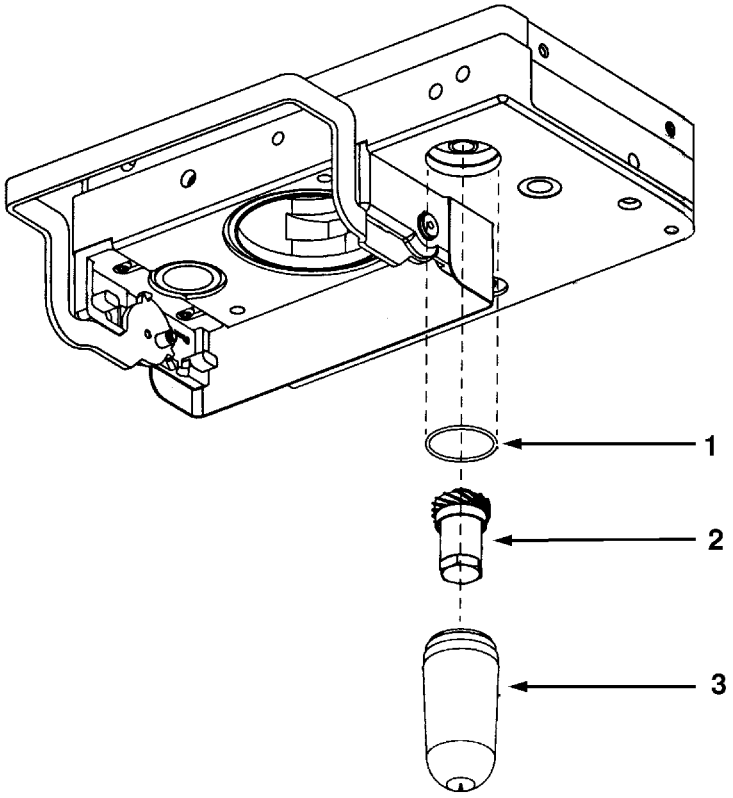
# 5.2. Maintenance Procedures

To Replace the internal battery you must remove the control module from the anesthesia system and remove the cover, see section "6/Repair Procedures" for more information.

## Exhalation Valve Maintenance

See the Operation and Maintenance manual for maintenance and parts.

## Supply Gas Inlet Filter




1. O-ring, install onto filter bowl prior to installation
2. Element assembly
3. Filter bowl

**Figure 5-1**
Supply gas filter, Filter assembly with bowl 1503-3319-000, Filter element 1503-3320-000

**CAUTION: ⚠ Cross threading the filter bowl may cause debris to accumulate on the filter resulting in shorter useful life of the filter.**

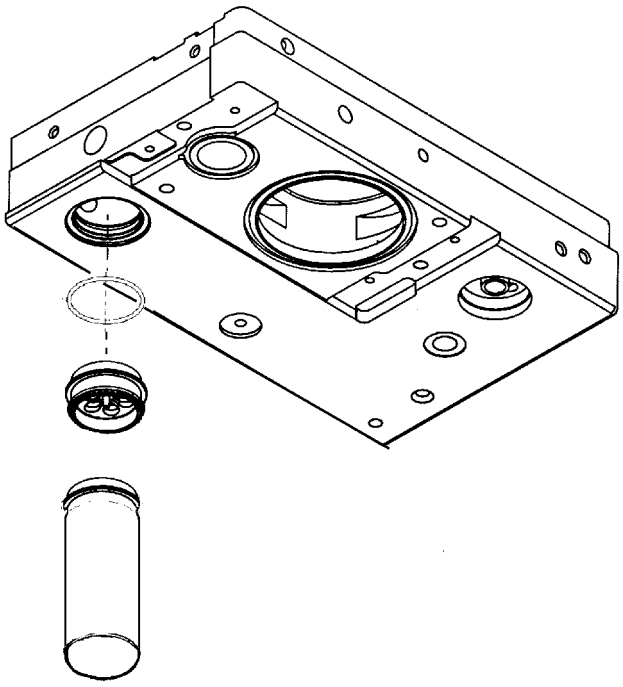
**CAUTION** ⚠ **Once you start the threads on the filter bowl, with the O-ring mounted to the bowl, do not back out the filter bowl unless you take the it all the way out and restart the mounting. If the bowl is partially unscrewed or backed out from the manifold seat, the O-ring will slip out of place and result in an unacceptable leak.**

## Free Breathing Valve Maintenance

1. Remove the deflection tube of the free breathing valve.

**CAUTION:** ⚠ **The deflection tube will collapse and tends to close off if it is stored for a period of time without something to hold it open in its original shape.**

2. Unscrew the valve seat from the bottom of the control module manifold, it should be hand tight.



121-6/14

**Figure 5-2**
Free Breathing Valve deflection tube and seat removal

3. Inspect the flapper and valve seat for nicks, debris and cleanliness.
4. Pull the tail of the new free breathing valve flapper through the center of the valve seat until it locks in place.
5. Trim the tail in line with the bottom edge of the valve seat, see figure 5-3.

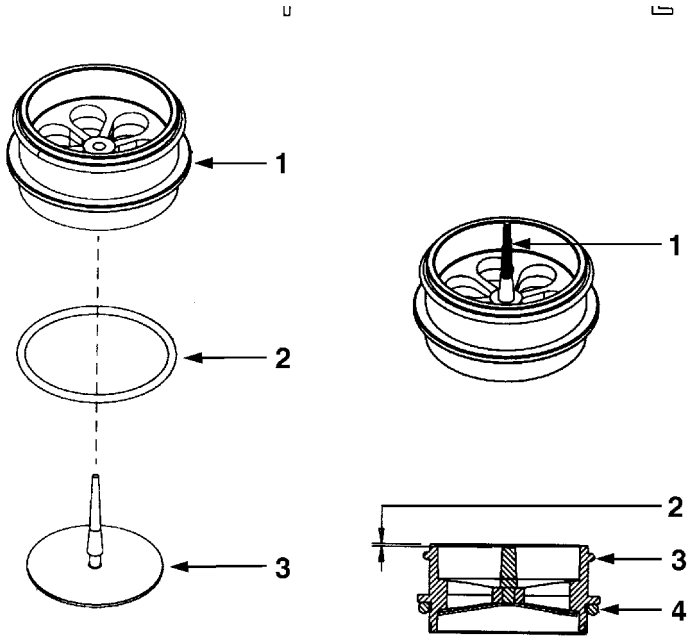



**Figure 5-3**
Free Breathing Valve flapper replacement

6. Replace the O-ring. Lubricate with a thin film of KRYTOX™.
7. Back the seat threads counter clockwise until you feel the thread engage. Hand screw the assembly into the manifold.
8. Replace the deflection tube on the valve. The tube has a rolled edge. Ensure that the edge slips over the ridge of the valve seat.

# 6/ Repair Procedures

## 6.1.General

**WARNING:** ⚠ **Post-Service Checkout is required after you complete this section. You must perform section " 3/Post-Service Checkout" after performing any maintenance, service or repair. Failure to do so may result in patient injury.**

**WARNING:** ⚠ **When servicing the ventilator, extreme care must be taken to avoid introducing foreign debris, particularly metal chips generated by screw threads into the pneumatic flow passages of the ventilator. Failure to do so may result in damage to the flow valve and possible injury to the patient.**

Some of the illustrations in this section have callouts listed with the figures. Others have numbers on the illustrations that correspond as references to procedure numbers.

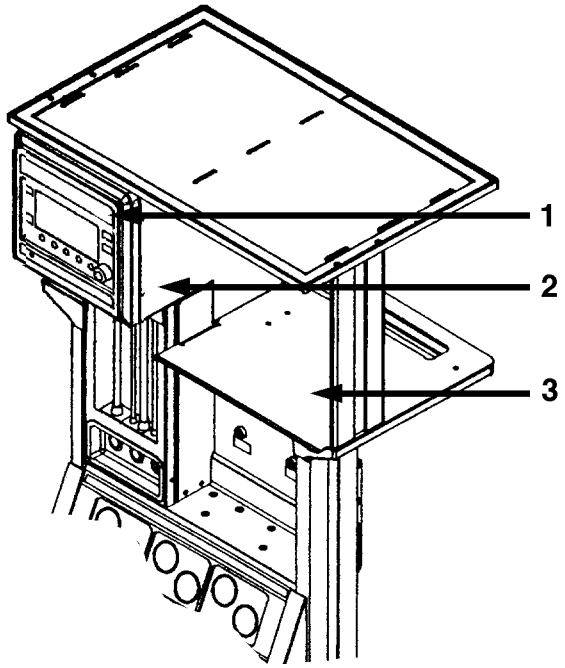
## Assemblies -- tools for removal and installation

| Description, subassembly | Tools to remove/replace |
|---|---|
| Top Cover | Pozi Driv* screwdriver, No. 2 |
| Gnd wires<br>top cover<br>power module<br>chassis<br>Isolation transformer | <br><br>7 mm nut driver or open-end wrench<br><br>7 mm nut driver for ground wire - 10 mm nut driver for large mounting bolt and Nyloc nut |
| Encoder removal | 14 mm nut driver for mounting nut |
| Front Panel | 2.5 mm hex wrench |
| Display board | 7 mm nut driver and 5.5 mm nut driver |
| Microcontroller board | 7 mm nut driver & offset flat blade screwdriver |
| Power Supply board | 7 mm nut driver & offset flat blade screwdriver |
| PCB removal | Straight blade screwdriver, offset |
| Power module | 7 mm nut driver |
| Pressure Sensing Switch | 2 mm hex wrench |
| Drive gas check valve assy | 3 mm hex wrench |
| GIV cap removal | Tru arc tool (Hi Tech No. 1221-5) |
| Inlet valve body | 3 mm hex wrench |
| Solenoid on inlet valve body | 1.5 mm hex wrench |
| Mechanical over pressure bleed off valve (MOBO) | 3 mm hex wrench, 2.5 mm hex wrench and alignment tool Stk. No. 1503-3124-000 |
| Flow control valve | 3 mm hex wrench |
| Regulator, non-relieving **(note:** do not loosen/remove Phillips head screws) | 4 mm hex wrench |
| Exhalation valve handle mounts | 2.5 mm hex wrench |
| Pneumatic manifold from chassis | 2.5 mm hex wrench |
| Power cord guard | Pozi Driv* screwdriver, No. 2 driver |
| Alarm speaker | 5 mm open end wrench or nut driver |
| Flash EPROM Removal | 32 pin PLCC Chip Extractor |

*POZI-DRIV Trademark Phillips Screw Co.

## 6.2. Removing the 7900 ventilator from the Ohmeda Excel/Modulus SE Gas Machine

There are two versions of 7900 ventilator/anesthesia machine mounting, Integrated and non-integrated.




1. **Ventilator**
2. **Ventilator shroud**
3. **Middle shelf**

**Figure 6-1**
Excel 210 with mid-shelf and integrated 7900 ventilator

**Integrated;** the ventilator fits in a shroud which has a latching back cover.

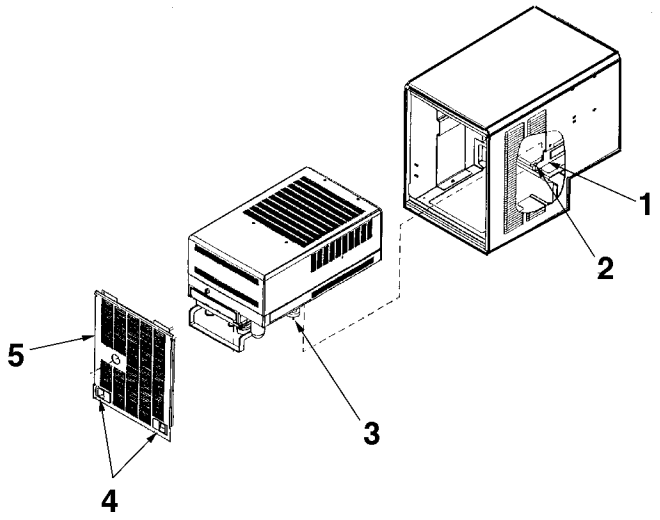
### Removing the 7900 ventilator from the integrated machine

Remove the rear panel from the gas machine ventilator shroud.

1. Push the locking clips on the panel toward the center.
2. Allow the panel to hang from its retaining cord.

**CAUTION:** ⚠ **Do not pull the exhalation valve manifold hoses straight down from the block assembly to remove them. Too much force is needed if you pull straight down. This added force can cause the hoses to release suddenly and possibly cause damage to the valve block or cause injury to the person removing the hose. To remove the hoses, use a careful, light twisting, back and forth movement while you apply pressure downward.**

3. Remove the dual hose for drive/return gas connecting the bellows to the exhalation valve and remove the exhaust hose from the exhalation valve manifold.




1. **Track on which the ventilator mounts in the Excel/Modulus SE Gas Machine**
2. **Slot into which the locking screw fits for secure mounting**
3. **Locking screw, holds the ventilator in place on the track when tightened**
4. **Rear panel locking tabs, push toward the center to release cover**
5. **Rear panel of the Excel/Modulus SE.**

**Figure 6-2**
Removing the ventilator from an Excel/Modulus SE Anesthesia Gas Machine

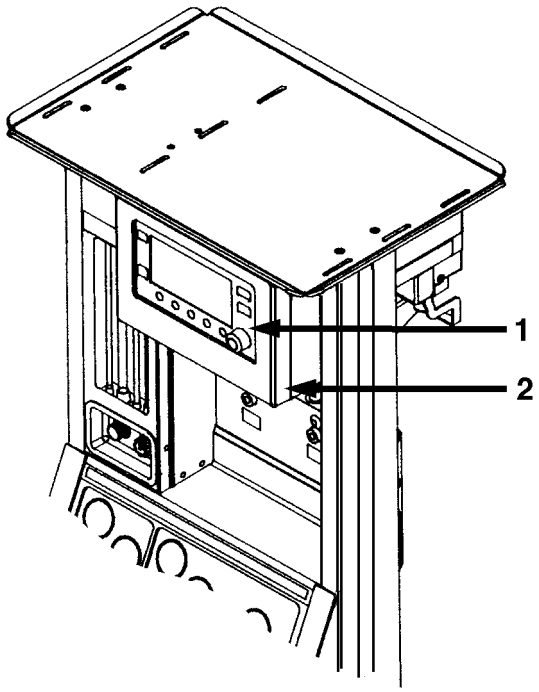
4. Unplug the ventilator power cord from the outlet box and thread it out through the opening made by cover removal.
5. Disconnect the gas supply hose from the gas machine power outlet and thread it out through the opening made by panel removal.
6. Loosen the securing knob under the ventilator on the right hand side.
7. Pull the ventilator back so it is flush with the back of the gas machine housing.
8. Remove the cable from the ventilator to the SIB board and the RS232 serial port connection if applicable.

**CAUTION: ⚠ The ventilator weighs approximately 40 pounds. Use care in its removal.**

9. See Section 6.3, service shelf setup

## Removing the 7900 ventilator from the non-integrated machine

The non-integrated ventilator mounts on a shelf which mounts into a shroud that is open in the rear and has rear and bottom access to hoses or cables.

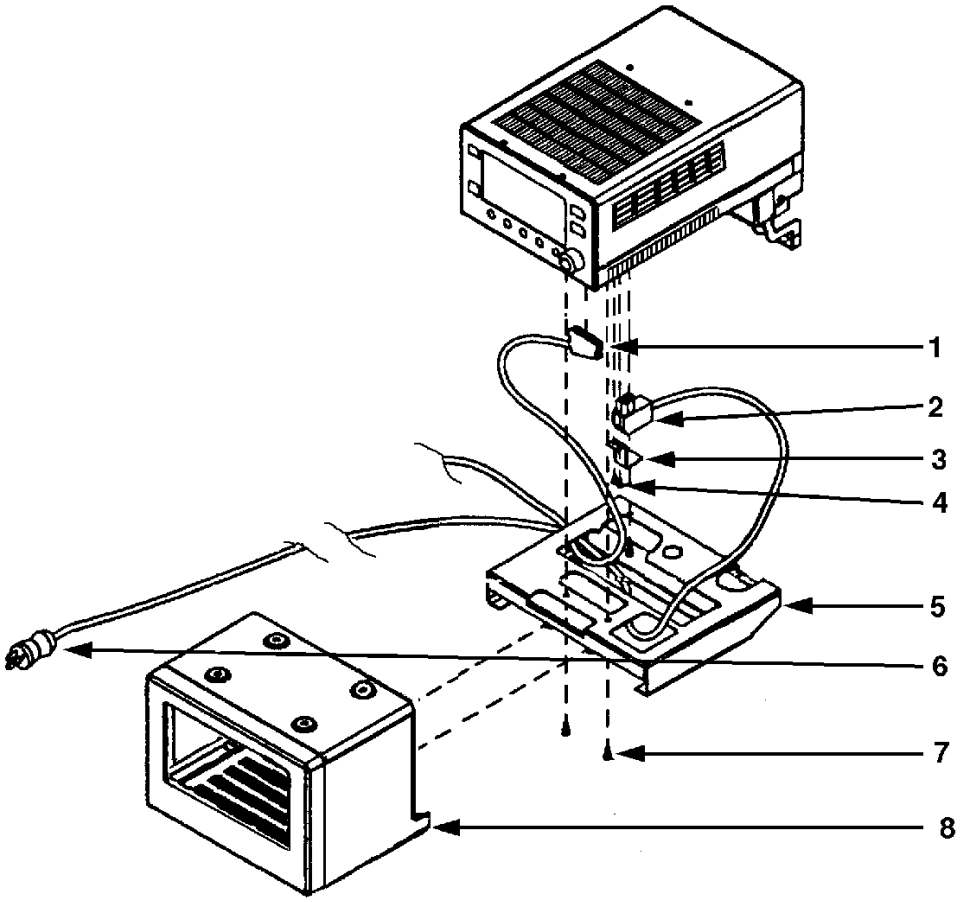



1. **Ventilator**
2. **Ventilator shroud**

**Figure 6-3**
Excel 210 without mid-shelf and non-integrated 7900 ventilator

**Non-integrated;** the anesthesia machine has no mid shelf and the 7900 fits in a shroud mounted to the under side of the top shelf

**CAUTION:** ⚠ **Do not pull the exhalation valve manifold hoses straight down from the block assembly to remove them. Too much force is needed if you pull straight down. This added force can cause the hoses to release suddenly and possibly cause damage the valve block or cause injury to the person removing the hose. To remove the hoses, use a careful, light twisting, back and forth movement while you apply pressure downward.**




1. **Cable that connects the ventilator to the anesthesia machine SIB.**
2. **Power cord connector to ventilator.**
3. **Power cord retainer bracket.**
4. **Power cord retainer bracket mounting screws.**
5. **Ventilator mounting shelf, slides into anesthesia machine shroud.**
6. **Power cord, plugs into the anesthesia machine electrical outlet box.**
7. **Ventilator shelf mounting screws, mounts the shelf to the bottom of the ventilator chassis.**
8. **Ventilator shroud. Mounts onto the top shelf and has a front bezel**

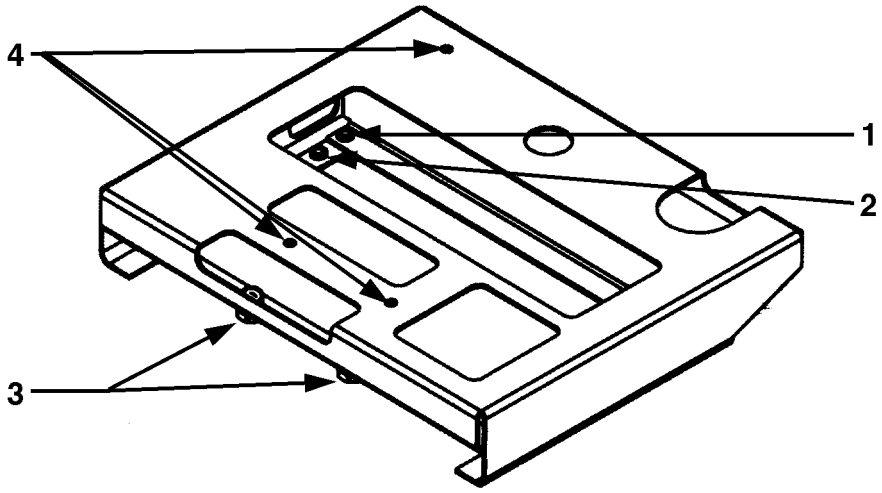
**Figure 6-4**
Non-integrated 7900 ventilator and mounting tray insertion

1. Remove the dual hose for drive/return gas connecting the bellows to the exhalation valve.
2. Remove the exhaust hose from the exhalation valve manifold.
3. Loosen the thumb screws (2) which hold the ventilator mounting tray in the key slots of the shroud.

4. Slide the mounting tray and ventilator out the rear of the shroud far enough to access the power cord and supply gas hose.
5. Disconnect the gas supply hose.
6. Remove the two mounting screws; remove the bracket and power cord.
7. Disconnect the cable from the ventilator that goes to the SIB in the machine.

**CAUTION: ⚠ The ventilator weighs approximately 40 pounds. Use care in its removal.**

8. Remove the 7900 Ventilator and mounting tray from the anesthesia machine.
9. It is necessary to remove the mounting tray to set the ventilator on the service shelf. Remove the three mounting screws from the tray.
10. See service shelf setup



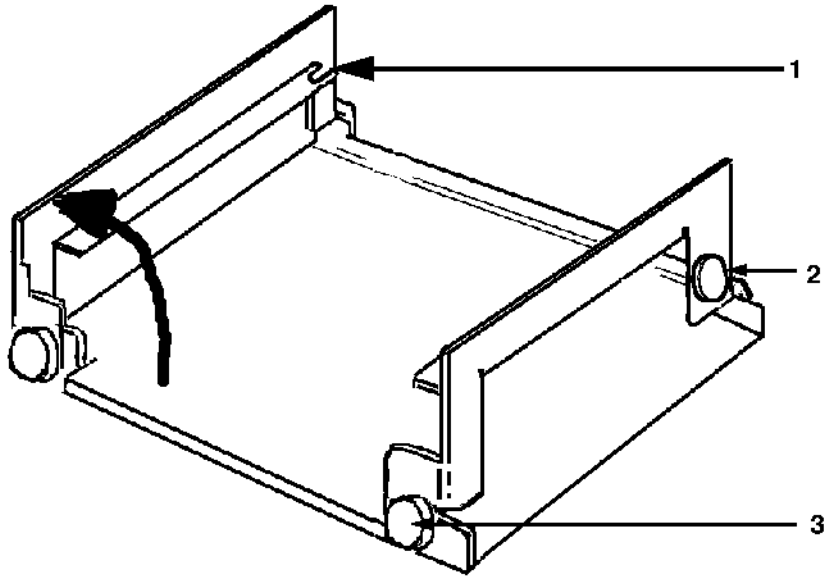

1. **Threaded nut for thumb screw lock bolt - one on each side of tray**
2. **Threaded nut for shipping screw**
3. **Locating pins to center and locate the ventilator properly**
4. **Clearance holes for tray mounting to ventilator chassis**

**Figure 6-5**
Ventilator mounting tray

## 6.3. Setting up the Service Shelf

The service shelf folds for easy storage. When setting up ensure the four locking screws are secure.

**CAUTION:** ⚠ **The circuit boards are electrostatic sensitive. Set the 7900 service shelf on an anti-static work station and wear a wrist grounding strap while working on the boards.**




1. **Notch for locking screw on the ventilator**
2. **Spare locking knob**
3. **Locking knobs (4). Hold the service shelf in position when unfolded to hold the ventilator while servicing**

**Figure 6-6**
Setting up the service shelf

1. Ensure the service shelf is setup on the anesthesia machine's work surface.

**CAUTION:** ⚠ **The ventilator weighs approximately 40 pounds. Use care in its removal.**

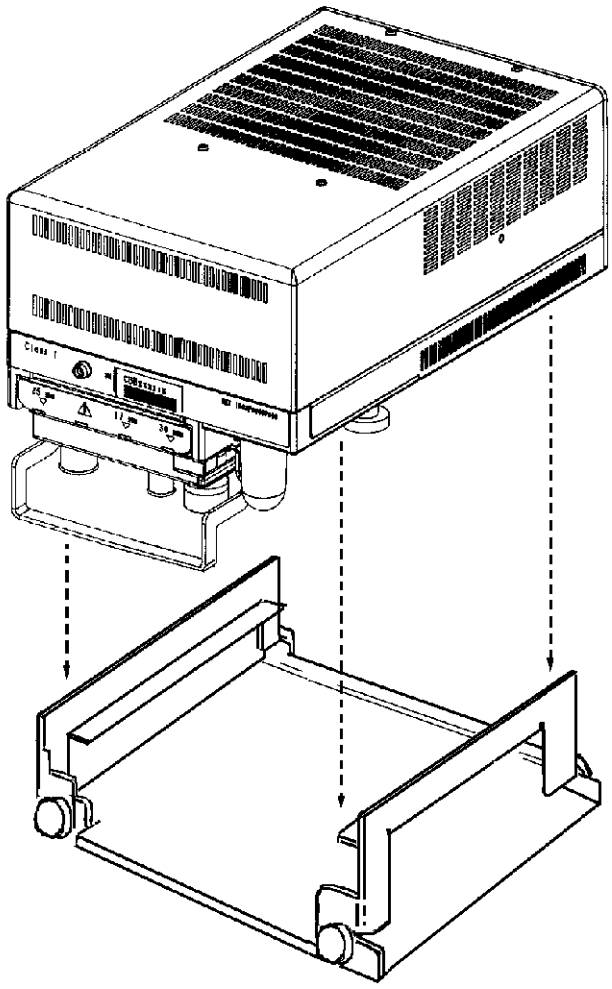
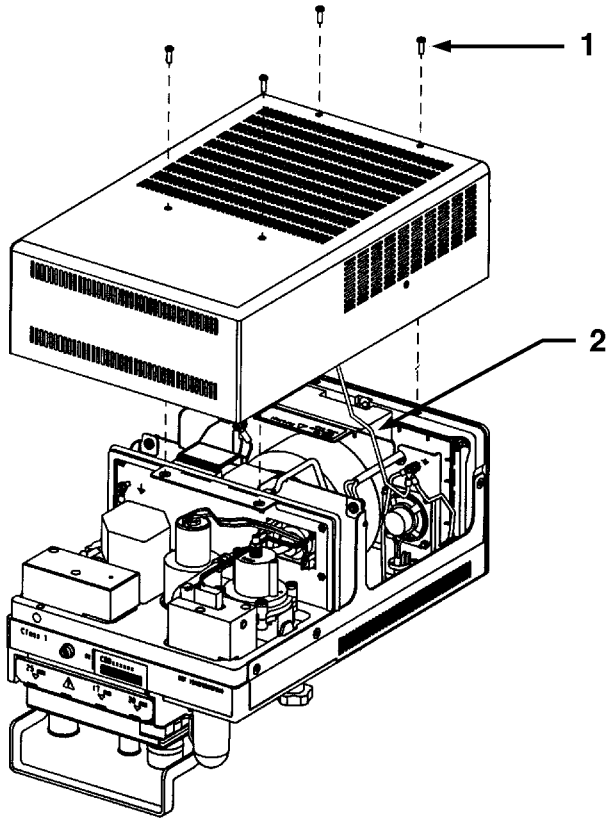


**Figure 6-7**
Put the ventilator on the service shelf

2. Arrange the ventilator so the rear is toward the left side of the gas machine.
3. Set the ventilator down on the service shelf so the locking screw fits below the mounting rail. Slide ventilator toward the front on the rails so locking screw slides in the notch. Tighten the securing knob to hold the ventilator to the service shelf.

**CAUTION:** ⚠ **The ventilator must sit on the left edge of the gas machine work surface to clear cables and hoses. Use care to prevent the ventilator from slipping off the surface and possibly causing damage to the ventilator or injury to the person servicing the ventilator.**

## 6.4. Removing the top cover

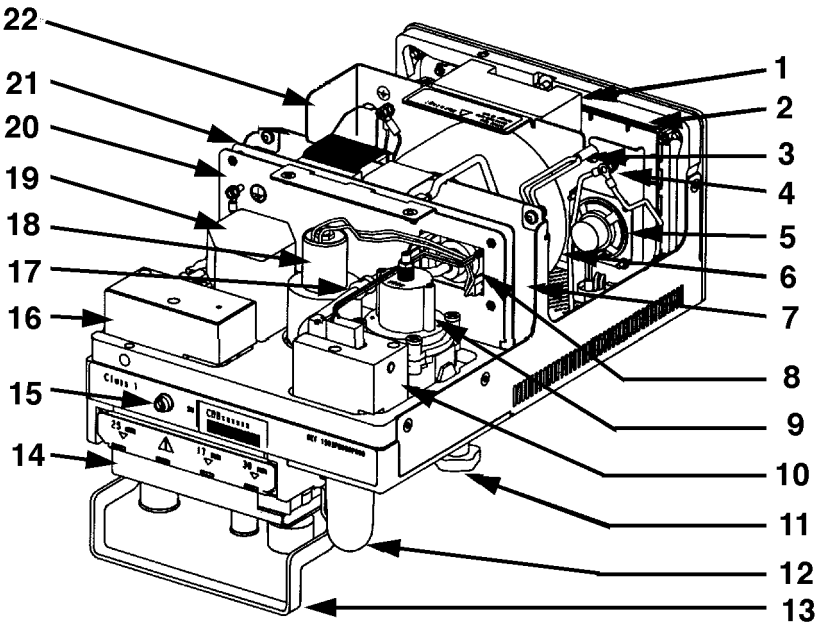



1. **Top cover mounting screws (4)**
2. **Ground wire, do not pinch when replacing cover**

**Figure 6-8**
Removing the top cover screws and cover

Once the ventilator is secure upon the service shelf and firmly located on the gas machine work surface, remove the four screws holding the louvered cover to the ventilator chassis. Remove the cover for access to the internal pneumatic assemblies and circuit boards.

Remove the ground wire from the top cover which connects the cover and chassis. Set the cover aside in a safe place.




1. Battery retainer
2. Front panel board
3. Battery harness
4. Ground wires
5. Speaker
6. Isolation transformer
7. Power supply board
8. Pressure transducer
9. Regulator
10. Gas inlet valve (GIV)
11. Lock knob for mounting
12. Supply gas filter
13. Locking handle
14. Exhalation valve block (manifold)
15. Pneumatic bleed resistor
16. Mechanical over pressure valve (MOBO)
17. Pneumatic quick connect
18. Flow control valve
19. Drive gas check valve
20. Pneumatic/electronic barrier
21. Microcontroller board
22. Power module chassis

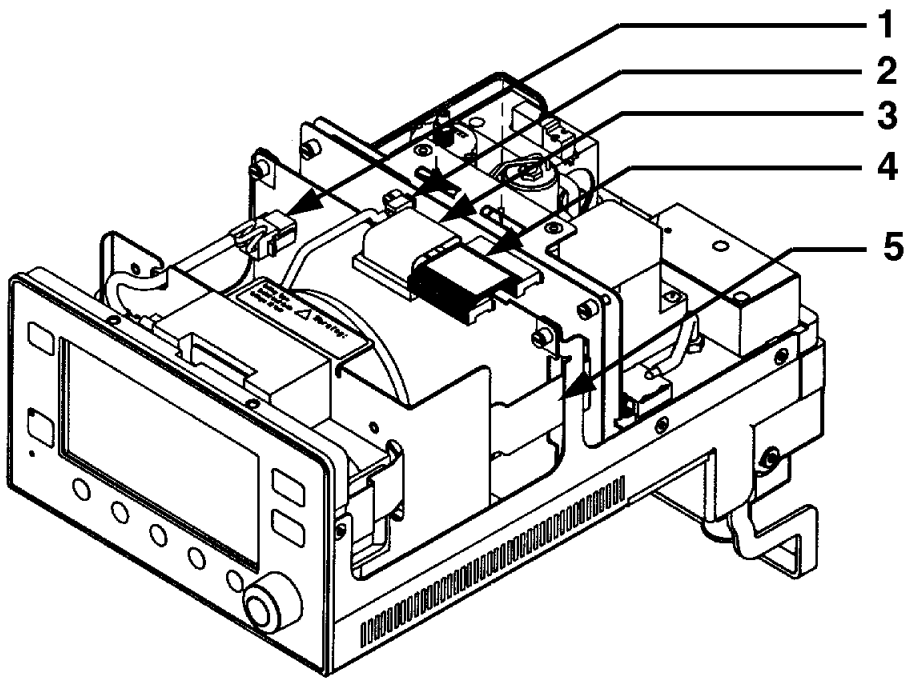
**Figure 6-9**
Sub assembly locations reference

## 6.5. Printed circuit board and power module removal

### Removing the Power Supply circuit board and the Microcontroller circuit board

**Note:** To remove the microcontroller circuit board you first must remove the power supply circuit board.

### Removing Power Supply circuit board

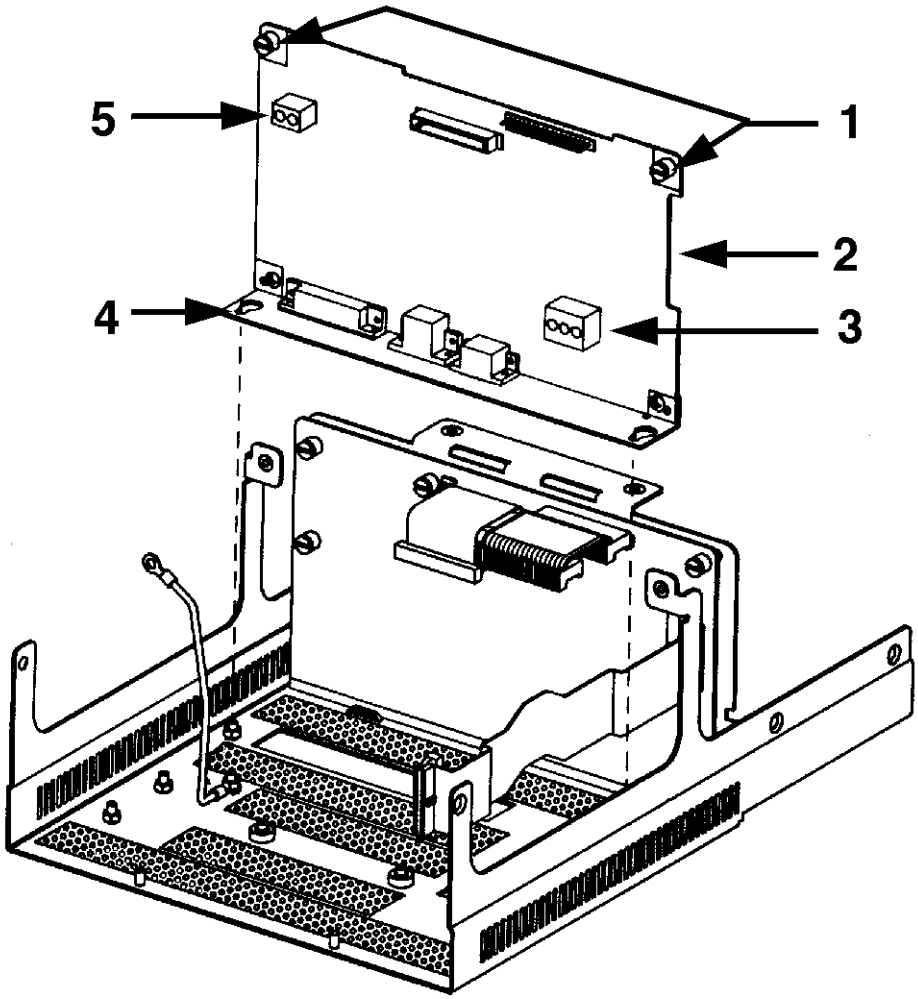



1. **Battery cable connector (J1)**
2. **Alarm speaker connector to microcontroller board (J1)**
3. **Ribbon cable microcontroller board to power supply board (J2)**
4. **Ribbon cable microcontroller board to power supply board (J3)**
5. **Ribbon cable microcontroller board to front panel board (J5)**

**Figure 6-10**
Disconnecting cables for circuit board removal

If removing the power supply board or the microcontroller board, remove the following connectors; see illustration numbered callouts that correspond to the following steps.

1. Disconnect the battery cable connector (J1) from the power supply board. Connector has lock tabs.
2. Disconnect the ribbon cable connector (J2) between the microcontroller board and the power supply board. Note the connector has lock tabs. Squeeze to release.
3. Disconnect the second ribbon cable connector (J3) between the micro controller board and the power supply board.
4. Disconnect the ribbon cable connector (J5) between the microcontroller board and the front panel circuit board. Connector has lock tabs. Note the routing of this cable through the slot in the chassis.
5. Disconnect the cable connector (J1) from the alarm speaker to the microcontroller board.
6. Not shown. Disconnect the cable connector (J4) from the isolation transformer to the power supply board.
7. Completely loosen the two (2) captive securing screws at the top two corners of the board. It may require an off-set, flat-blade screwdriver to loosen initially.
8. Use the 7 mm nut driver to loosen the hex nuts on the bottom angle mount of the board. It is not necessary to take the nuts completely off. The chassis studs are in key-hole slots, slide the board back and lift it off and out of the chassis.

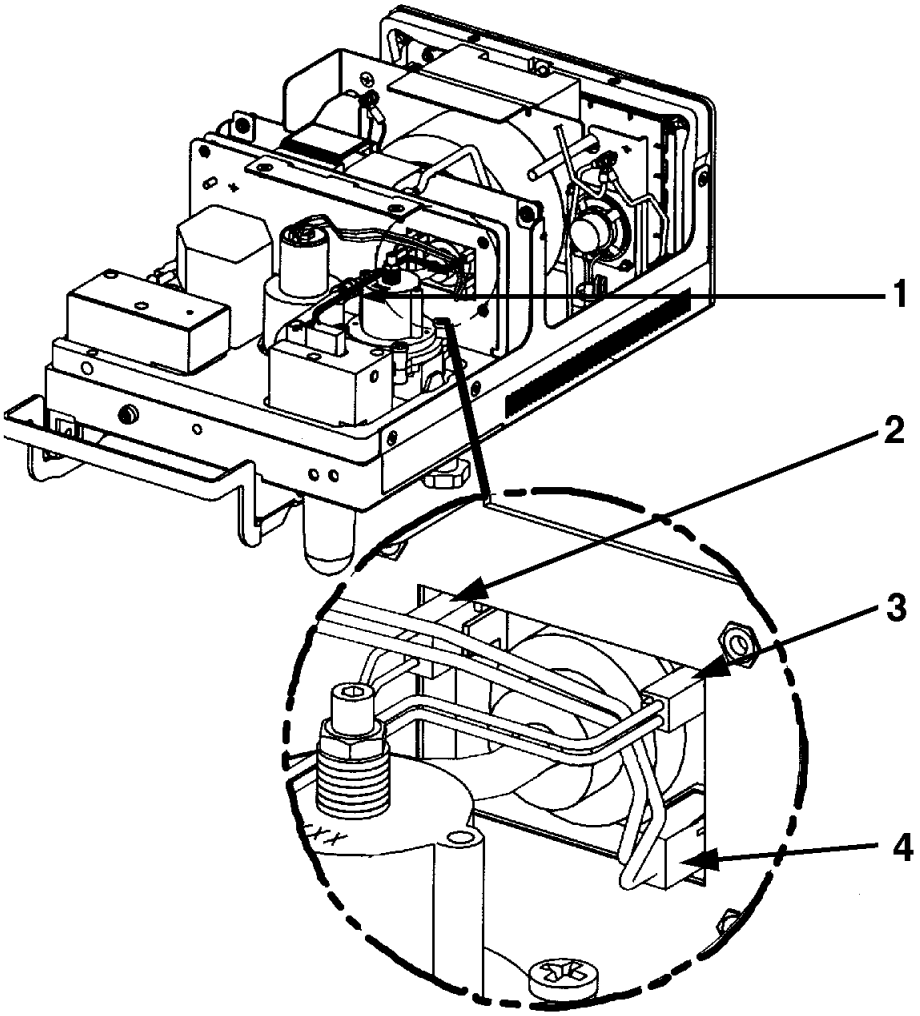



1. **Power supply board has two captive securing screws. Finger tighten, low torque.**
2 **Power supply board.**
3. **Power supply board connector for isolation transformer cable.**
4. **Key hole slots for angle mounting flange.**
5. **Battery connection (J1) to power supply board. See step 5 in previous procedure.**

**Figure 6-11**
Removing the power supply board

### Removing Microcontroller circuit board

**CAUTION:** ⚠ **Disconnect the internal battery before attempting to remove or repair any circuit board. Failure to do so may damage the internal electronics.**




1. **Pneumatic quick-connect fitting from main manifold**
2. **Connector from pressure sensor switch (J8)**
3. **Connector from GIV solenoid (J6)**
4. **connector from flow valve (J7)**

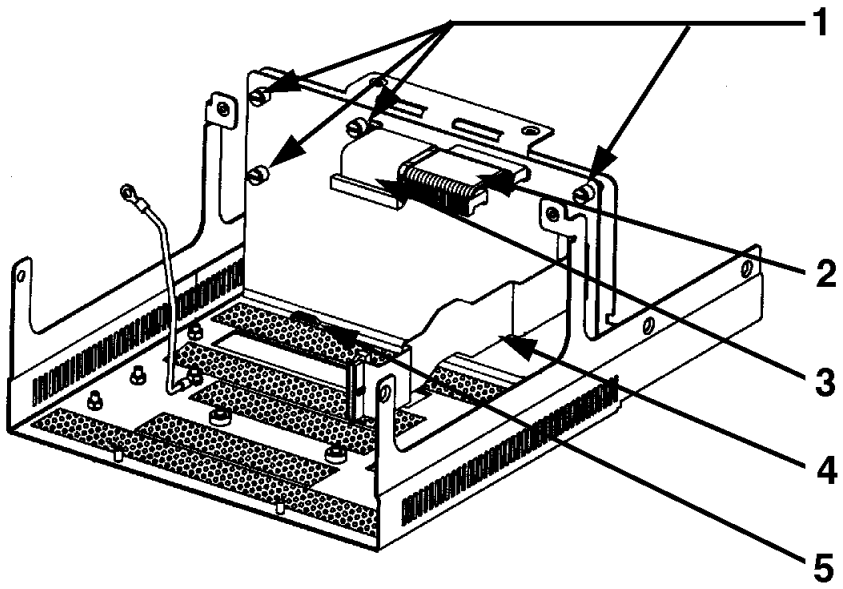
**Figure 6-12**
Microcontroller board connector and cable identification around manifold pressure transducer

If removing the microcontroller board, remove the following connections, see illustration numbered callouts to follow the steps below listed. Board removal requires power supply board removal to clear the pneumatic fitting and the transducer mounted on the microcontroller board.

**CAUTION:** ⚠ **The circuit boards are electrostatic sensitive. Use an anti-static work station and wear a wrist grounding strap.**

1. Disconnect the cable connector (J8) between the pressure sensor switch to the transducer.
2. Disconnect the cable connector (J6) from the solenoid switch on the gas inlet valve to the microcontroller board.
3. Disconnect the cable connector (J7) from the flow control valve to the micro controller board.
4. Disconnect the pneumatic line from the manifold block to the transducer at the quick-connect fitting.

Cable disconnects in figure 6-10 and the following releases the microcontroller board and the power supply board from all cable connections for removal.




1. **Captive mounting screws (4)**
2. **Ribbon cable microcontroller board to power supply board**
3. **Ribbon cable microcontroller board to power supply board**
4. **Ribbon cable microcontroller board to front panel board**
5. **Guide slots for microcontroller board in chassis (3)**

**Figure 6-13**
Microcontroller board removal

See previous illustration numbered callouts for the following steps.

1. Loosen the four (4) captive securing screws all the way, three across the top of the board and one (1) half way down on the left side of the board. They may require an off-set, flat-blade screwdriver to loosen initially.
2. Ribbon cable between micro controller and power supply boards, see Figure 6-10 for cable disconnection.
3. Ribbon cable between micro controller and power supply boards, see Figure 6-10 for cable disconnection.
4. Ribbon cable between microcontroller board and front panel board, see Figure 6-10 for cable disconnection.
5. Cable disconnection and loosening the four securing screws in step 1, frees the microcontroller board for removal.
6. Lift the board out of its guide slots, tilt the board forward and carefully guide the mounted transducer and its pneumatic fitting through the opening in the pneumatic/electronic barrier.

**CAUTION:** ⚠ **When replacing the microcontroller board, be certain that the bottom of the board is aligned and inserted into the three guide slots in the chassis. Ensure all cables are properly reconnected and mounting screws tightened.**

### Firmware Replacement Procedure

**CAUTION:** ⚠ **The circuit board and EEPROM's are electrostatic sensitive. Use and approved static control workstation and wrist grounding strap.**

1. Place the Microcontroller Board on an approved static control workstation.

**CAUTION:** ⚠ **Use care not to damage the tubing board on the manifold transducer.**

2. Use a PLCC chip extraction tool to remove the two EEPROM's, U30 and U40. Insert the two prongs on the extractor tool into the slotted corners of the EEPROM socket.
3. Install the new EEPROM's, noting the label to ensure the correct chip is placed in the correct socket. Align the EEPROM notch with the socket notch and press the chip down firmly.

## Software Upload Procedure

The 7900 Ventilator software can be field upgraded using the Ohmeda Software Upgrade Tool software (1503-8019-000) and Field Upgrade 7900 Vent software. The Ohmeda Software Upgrade Tool must first be installed on a IBM or compatible PC, and at least one version of field upgrade software must be installed.

### Ohmeda Software Upgrade Tool

Parts and supplies required:

| | |
|---|---|
| 7900 Ventilator with an Excel SE or Modulus SE system | To provide system on/off and power |
| IBM or compatible PC | including at least one serial port (DB-9) and Microsoft Windows version 3.1 |
| Kit, Cable Software Upgrade, Service 7900 Vent includes:<br>Serial communications cable<br>Ohmeda Software Upgrade Tool installation diskette<br>Instructions | 1503-8019-000<br><br>1503-3126-000<br><br>1503-7007-000 |
| At least one field upgrade software kit | For example: Kit, Software Rev. 2.2, Field Upgrade 7900 Vent, Part # 1503-8021-000 |
| Virus scanning software | |

### To Install the Ohmeda Software Upgrade Tool

1. Turn on computer and enter Windows.
2. Quit all Windows applications excepting Program Manager (be sure to quit all applications including background items such as the Microsoft Office icons).
3. Insert the Ohmeda Software Upgrade Tool installation diskette in drive A.
4. From the File menu of the Program Manager or File Manager, choose Run.
5. Type **a:setup**
6. Follow the Setup instructions on the screen.
7. Run the virus scanning software to confirm no known viruses exist on the computer.

**Note**: In order to use the Ohmeda Software Upgrade Tool to perform an upgrade, first install at least one version of field upgrade software on the PC. If you do not install at least one version of field upgrade software, the Ohmeda Software Upgrade Tool will indicate that files are missing or corrupt during the upgrade procedure.

**To install 7900 software field upgrade**

The software in the Cable Software Upgrade kit must be installed before following these instructions.

1. Turn on the computer and enter Windows.
2. Insert the 7900 field upgrade installation diskette in drive A.
3. From the File menu of the Program Manager or File Manager, choose Run.
4. Type **a:setup**
5. Follow the Setup instructions on the screen.
6. Run the virus scanning software to confirm no known viruses exist on the computer.

**To perform software upgrade**

1. Turn off power to the 7900 ventilator.
2. Double-click on the Ohmeda Upgrade Tool icon located in the Ohmeda Support Tools program group.
3. From the Setup menu of the Ohmeda Upgrade Tool, choose release. Double click on the file corresponding to the new release, for example, 7900_2_2.rls is 7900 software revision 2.2. Verify Comm Port is correct.
4. There are two choices, Step-by-Step or Quick Upgrade. Choose Step-by-Step and follow the instructions on the screen. Confirm the serial port used by the PC and the software version being loaded. If these are incorrect, choose Cancel and use the Setup menu to change these settings.
5. Continue to follow instructions on the screen until the upgrade procedure is complete. Once you are familiar with the upgrade procedure, the Quick Upgrade button allows you to perform the upgrade without the step-by-step instructions. You should follow the step-by-step process at least once for each software release, since the procedures may change from one release to the next.

When you have finished with the upgrade, perform the tests listed below for replacing the microcontroller board and/or EPROMs.

## Microcontroller board

Whenever you replace the microcontroller board and/or the EPROM's (U30 and U40), or perform the software upgrade, perform the following tests in the ventilator service mode.

Select the drive gas

Select the altitude

Cal O2 Sensor

Cal Flow Sensor

Cal Pressure Sensitivity

Cal Flow Valve

Cal Bleed Resistor

Perform the Post Service Checkout of the ventilator and Anesthesia system.

### Removing the front panel

1. Disconnect the ribbon cable (J2) from the front panel.
2. Use the 2.5 mm hex wrench to remove the two chassis mounting screws.

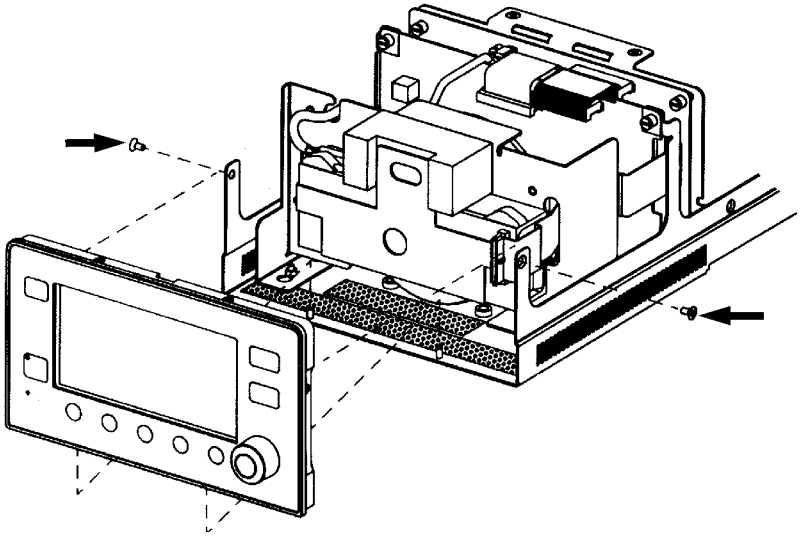


**Figure 6-14**
Front panel removal

3. Lift the front panel up to clear mounting pins and remove it from the chassis.

### Replacing the display board

1. Disconnect the ground wire from the front panel board using the 7 mm nut driver.

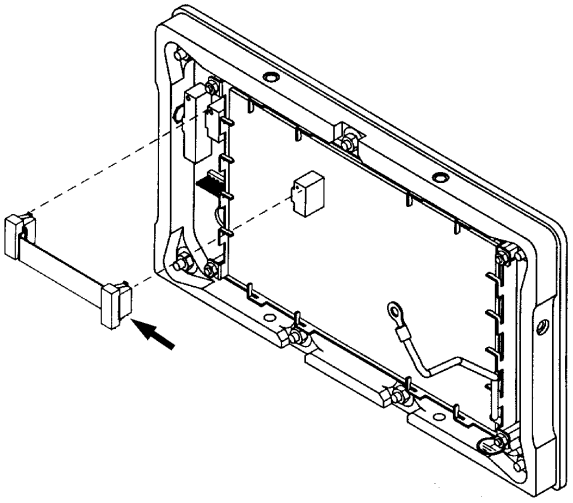


**Figure 6-15**
Disconnect cable.

2. Disconnect ribbon cable between display board and keyboard board. Squeeze locking tabs to release connectors.

3. Set the cable aside for reassembly.

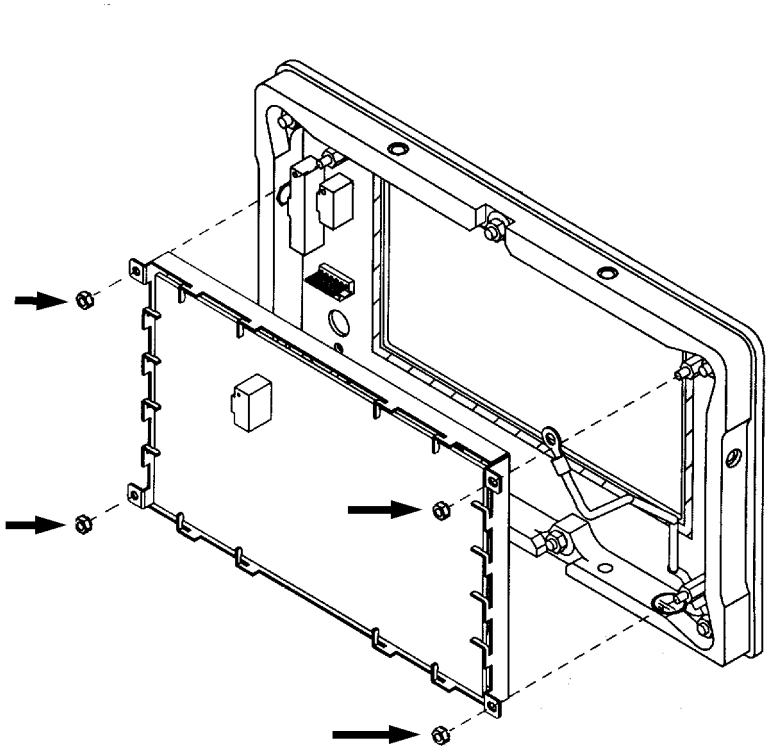
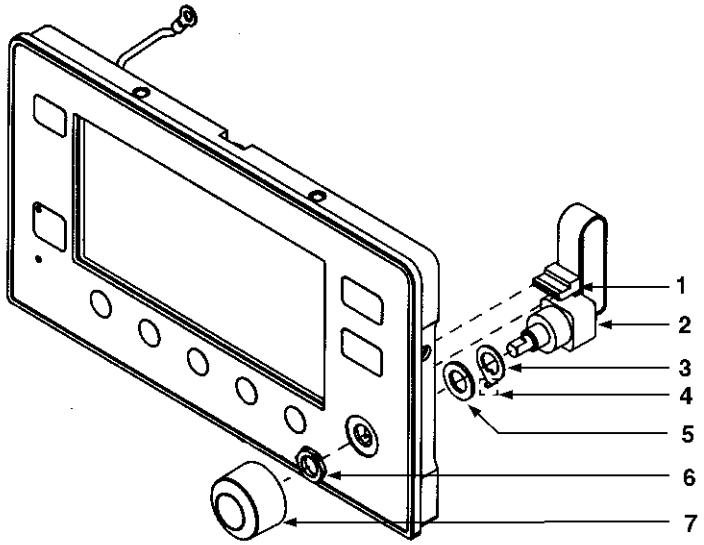


**Figure 6-16**
Remove display board

4. Use 5.5 mm nut driver to remove the four hex-head mounting nuts.
5. Lift out the display board.
6. When installing, check for debris and/or finger prints on the panel face. Clean with isopropyl alcohol as necessary.

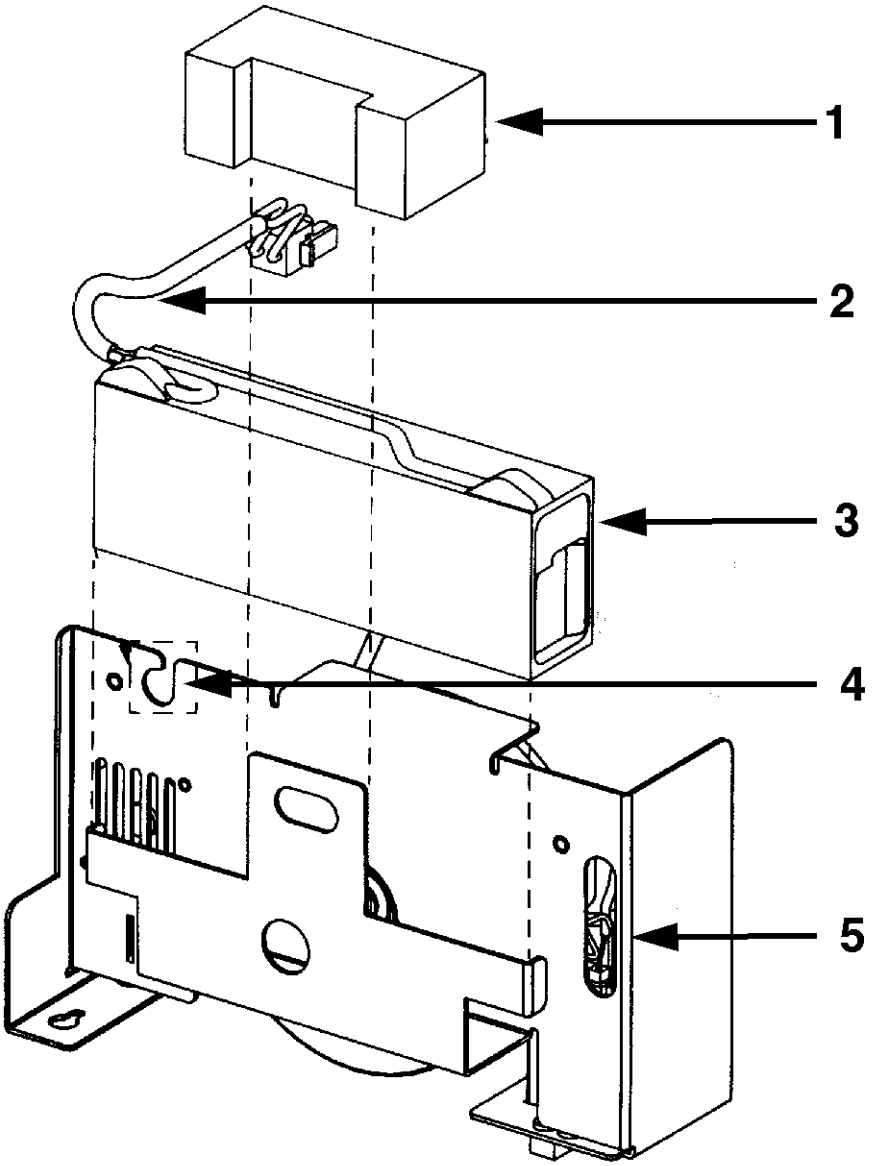
## Replacing the encoder switch




1. **Encoder harness, connect to front panel**
2. **Encoder switch**
3. **Locking washer**
4. **Tab, align tab into hole in circuit board**
5. **Flat washer**
6. **Mounting nut use 14 mm wrench**
7. **Knob, spring friction "D" shaft**

**Figure 6-17**
Replacing the encoder

### Removing the battery




1. **Foam battery retainer**
2. **Battery harness route through cutout, item 4**
3. **Battery**
4. **Hole for battery harness routing**
5. **Power module bracket assembly with slot for ribbon cable**

**Figure 6-18**
Battery removal

See previous illustration numbered callouts.

1. Remove the foam battery retainer.
2. Disconnect the battery cable connector from the power supply board.
3. Lift the cable out of the slot in the power module.
4. Remove battery and dispose of according to local regulations
5. Install a properly conditioned replacement battery in reverse order of removal

**Important**: Check the conditioning date marked on the replacement battery. Do not install a battery which is 60 days past the conditioning date. If the replacement battery is 60 days past the conditioning date, return the replacement battery or dispose of according to local regulations.

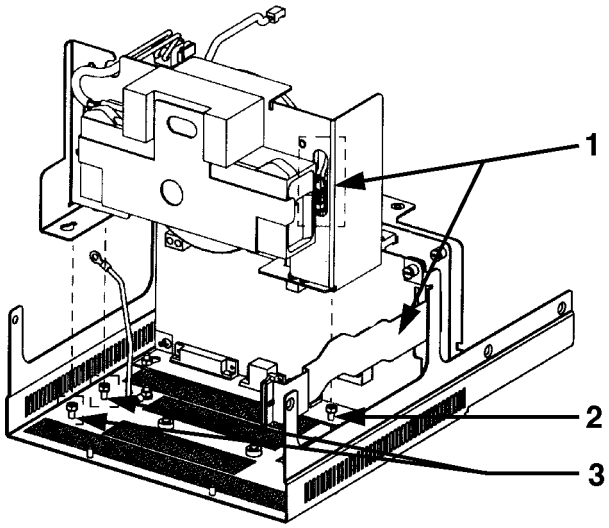
### Testing After Maintenance

6. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."
7. Charge the battery for 24 hours before returning the ventilator to clinical use.
    a Switch ON system power to turn ON the ventilator.
    b. If "Low Battery" appears, the message should go away within 5 minutes. If the message does not go away, the battery is not being charged properly.
    c. The system and ventilator must remain plugged in to charge the battery.

## 6.6. Replacing the isolation transformer

### Removing the power module

1. Disconnect the ribbon cable from the front panel. Squeeze the locking tabs on the connector.
2. Disconnect the alarm speaker cable from the microcontroller board.
3. Disconnect the isolation transformer cable from the power supply board.
4. If not already disconnected, disconnect the battery cable.

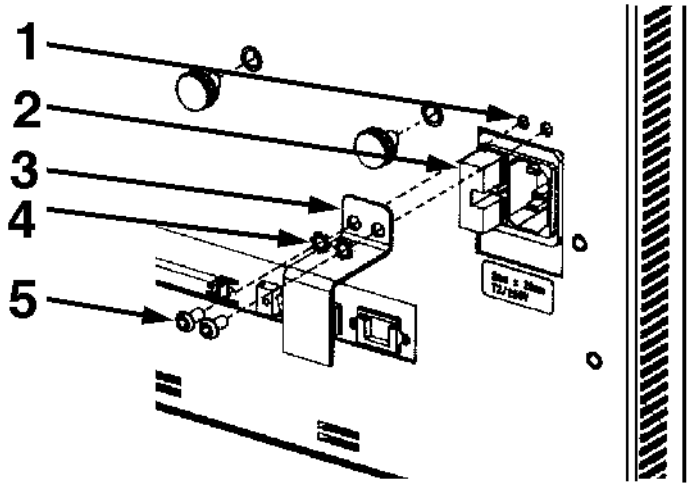



1. **Route ribbon cable through the slot in chassis**
2. **Hex nut mounting on stud**
3. **Hex nut mounting on studs**

**Figure 6-19**
Power Module removal

5. Use the 1.5 mm hex wrench to remove the screws from the a-c power cord retaining clamp. Disconnect the power cord from the a-c inlet connector. (See figure 6-20, item 5)
6. Use the 7 mm nut driver or open end wrench to disconnect the three ground wires from the power module.
7. Use the 7 mm nut driver to loosen the hex nuts on the angle brackets holding the power module to the chassis.
8. Align the nuts with the larger hole in the key hole slot and slide the power module back to gain access to the hex nut holding the ground wires.
9. When ground wires are disconnected, lift the power module out of the chassis.

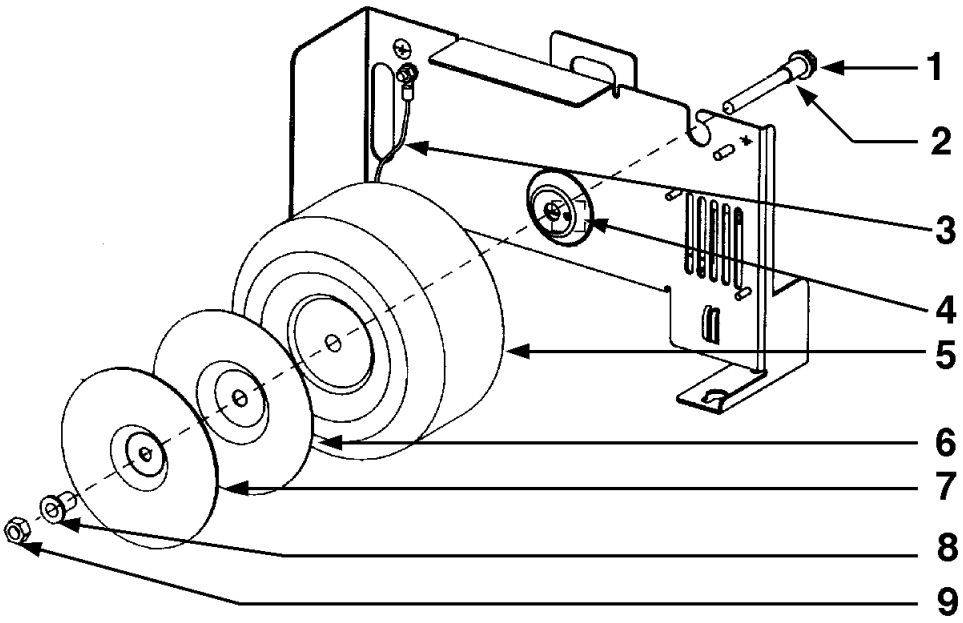
## Prepare power module for removal




1. **Threaded holes for mounting screws (item 5) to mount the power cord bracket.**
2. **Power cord fuse block**
3. **Power cord securing bracket**
4. **Lock washers No. 4 external**
5. **Bracket mounting screws 4x8 mm button/socket head**

**Figure 6-20**
Power cord removal

### Isolation transformer removal




1. **Transformer mounting bolt**
2. **Nylon sleeve**
3. **Transformer ground wire**
4. **Alignment hole**
5. **Transformer coil**
6. **Rubber insulator**
7. **Mounting plate**
8. **Nylon sleeve**
9. **Nyloc nut**

**Figure 6-21**
Isolation transformer removal

When you lift out the power module, the a-c power connector block comes out with the unit.

1. Disconnect the wire lug connectors from the transformer to the a-c connector block.
2. Use a 7 mm nut driver to disconnect the ground wire from transformer to power module chassis.
3. Use a 10 mm nut driver or wrench to loosen the transformer mounting bolt.
4. Hold the transformer with one hand while removing the hex-nut and bolt from the center of the transformer.
5. Replace the transformer in reverse order. However, ensure that the alignment pin on the transformer is inserted in the locating hole in the power module board prior to tightening the mounting nut and bolt.

### Alarm speaker removal

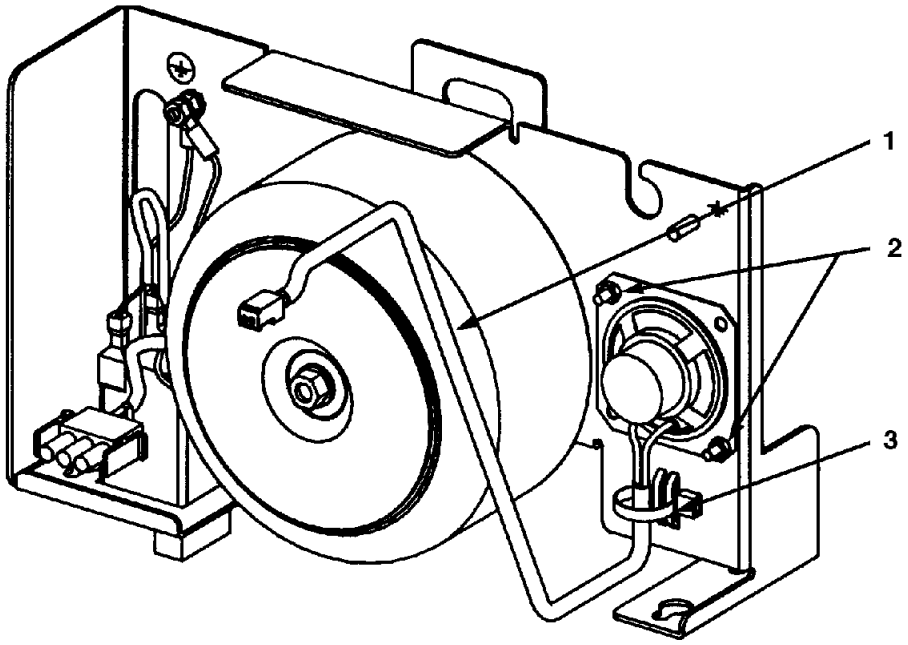



**Figure 6-22**
Alarm speaker removal

1. The power module must be removed from the chassis to gain access to the alarm speaker mounting nuts. This requires the disconnection of the alarm speaker cable from the microcontroller board (J1)
2. Clip the cable tie with a diagonal wire cutter, item 3 fig 6-22.
3. Remove the speaker mounting hex nuts from the studs on the microcontroller board with a 5 mm nut driver.
4. Reinstall or replace in reverse order.

### Power cord inlet removal

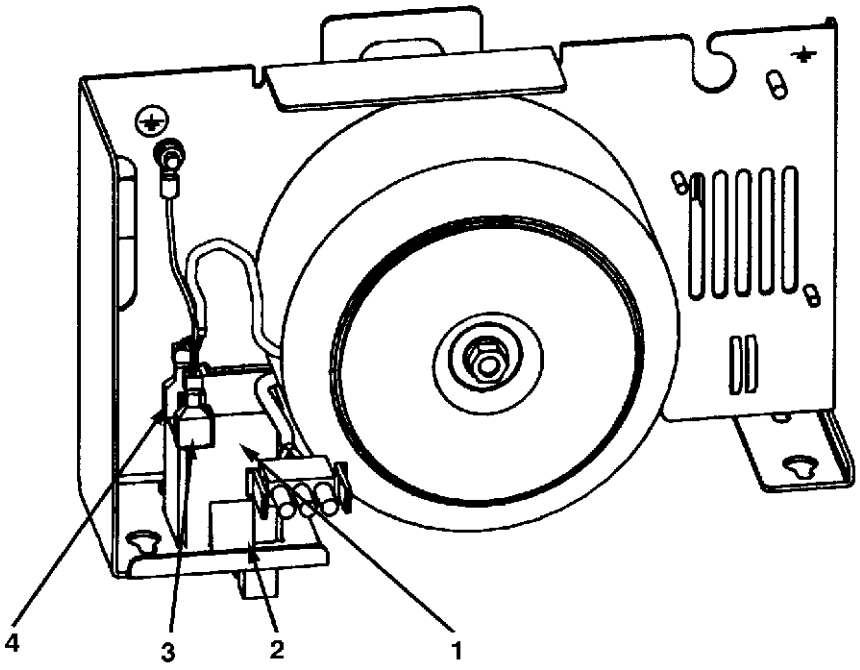



**Figure 6-23**
Power cord inlet connector removal

1. Item 1, figure 6-23 is the a-c inlet power connector where the two, 2 ampere line fuses are located. Fuses may be replaced without removal of the inlet connector.
2. Disconnect the white wire quick-connect terminal from the inlet connector assembly to the transformer. (Rear connection, see figure 6-23 item 4.)
3. Disconnect the ground wire quick-connect terminal from the inlet connector assembly to the ground lug on power module. (Middle connection.)
4. Disconnect the black wire quick-connect terminal from the inlet connector assembly to the transformer. (front connection, see figure 6-23 item 3.)
5. Depress the locking tabs on both sides of the assembly and lift the assembly out of the mounting hole in the power module.

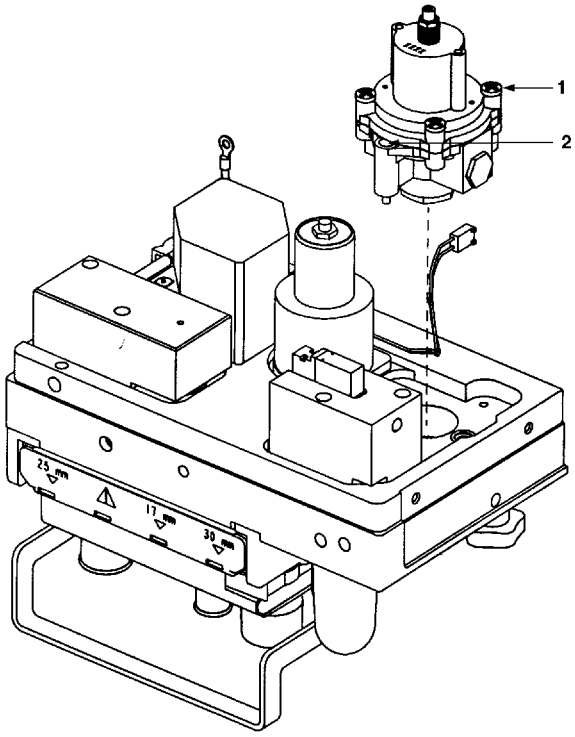
# 6.7. Pneumatic subassembly removal

As with the electronic circuit boards and the power module, each of the pneumatic subassemblies can be removed without having to remove other components.

**Note:** The subassemblies for removal are shown with other subassemblies removed in some cases.

## Removing the non-relieving regulator

The regulator is replaced as an assembly.




1. **Phillips head screws (4) DO NOT REMOVE**
2. **Captive regulator mounting screws (2)**

**Figure 6-24**
Regulator removal

1. The regulator is replaced as an assembly. Do Not remove the Phillips head screws (4) that hold the regulator together. Use the 3 mm hex wrench to loosen the two (2) captive mounting screws.
2. Lift out the regulator.
3. Inspect seat and O-rings for damage. Replace as necessary before replacing the regulator.

## Removing the flow control valve

1. Disconnect the cable connector (J7) from microcontroller board.

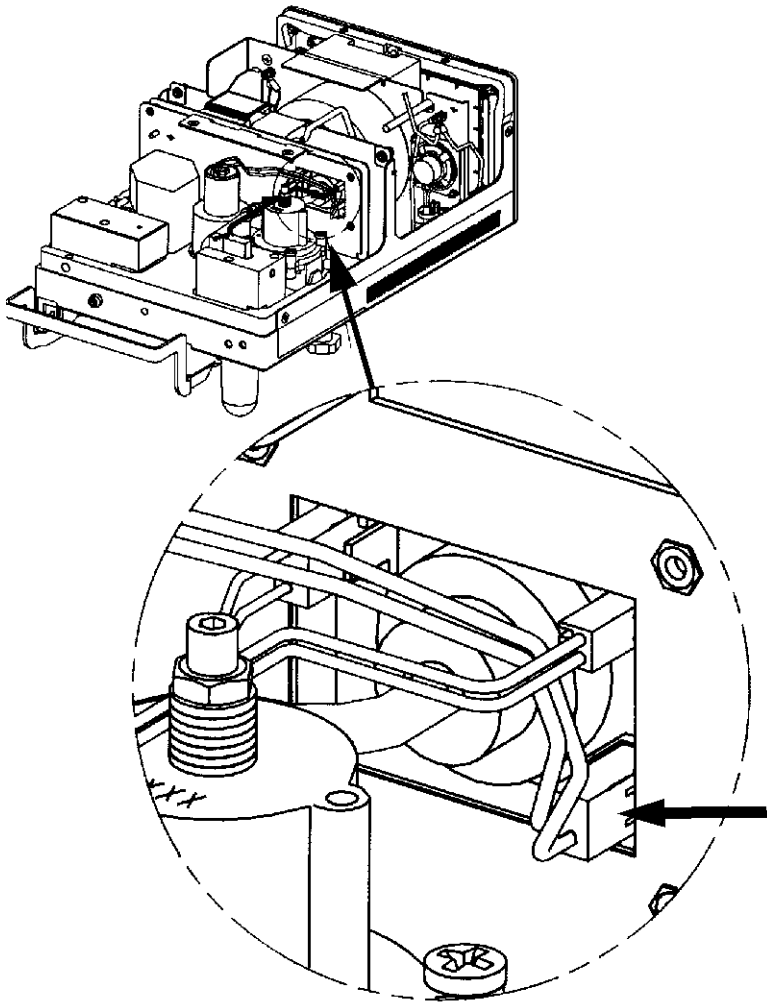
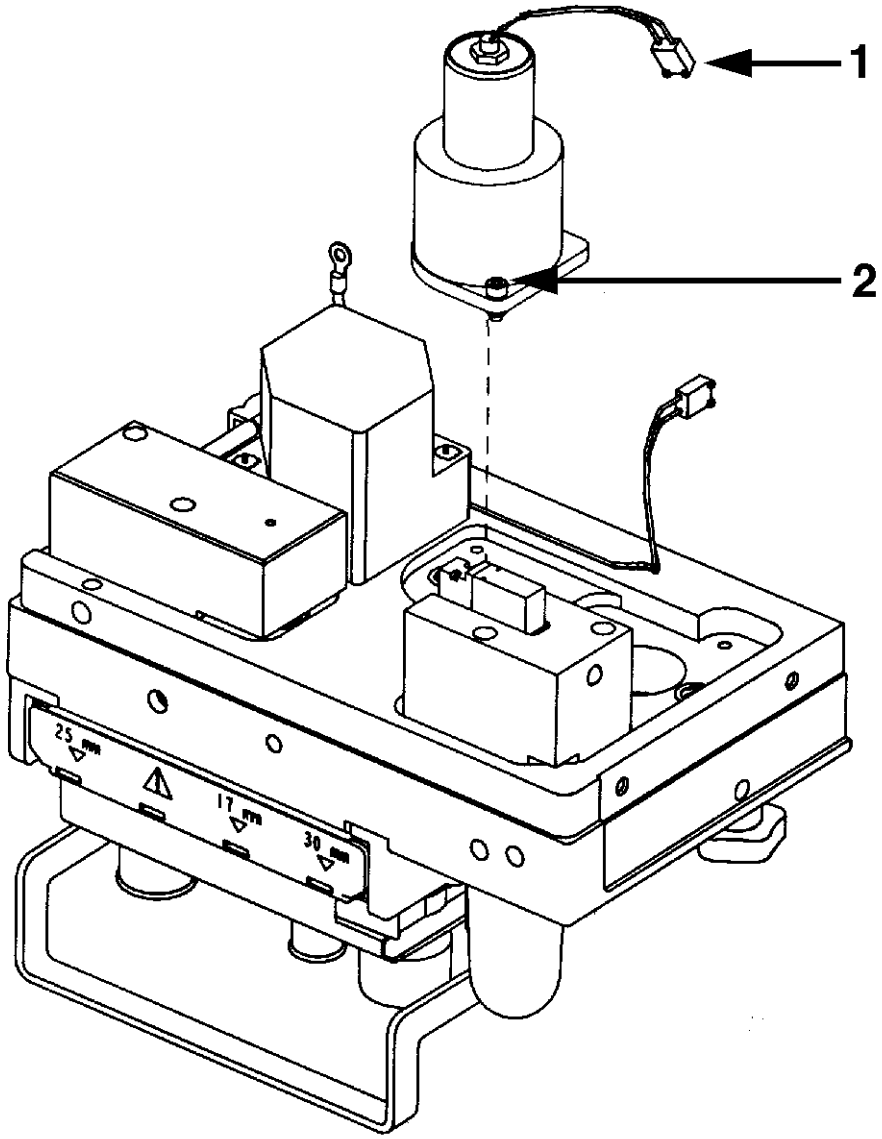


**Figure 6-25**
Disconnect the flow control valve cable

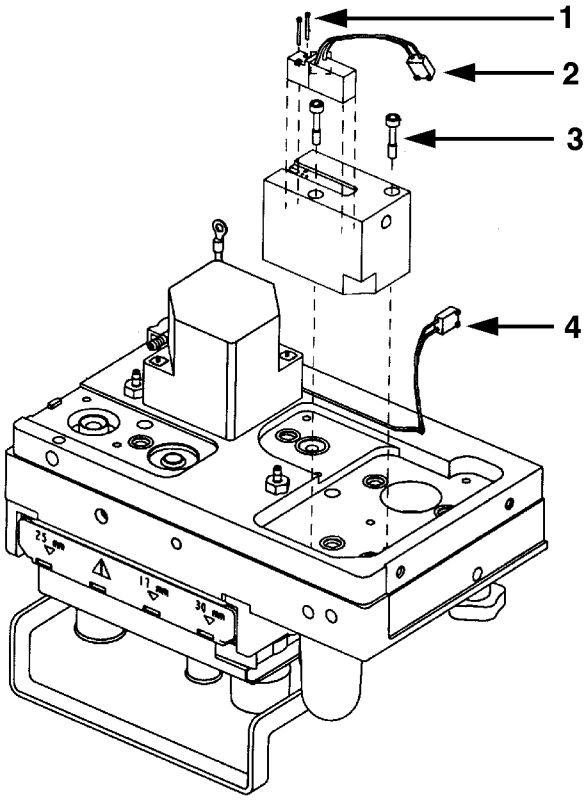
2. Use the 3 mm hex wrench to loosen the two (2) captive mounting screws and lift out the flow control valve. (See figure 6-26)
3. Examine the seat and two O-rings for damage; replace as necessary.




1. **Flow control valve cable connector to J7 microcontroller board**
2. **Captive mounting screws (2)**

**Figure 6-26**
Flow control valve removal

### Removing the solenoid and gas inlet valve assembly




1. **Solenoid socket head mounting screws 1.5 mm hex wrench**
2. **Cable connector to J6 microcontroller board**
3. **Captive mounting screws**
4. **Cable connector from pressure switch**

**Figure 6-27**
Inlet valve and solenoid switch removal

1. Disconnect the cable connector (J6) from the solenoid switch on the microcontroller board.

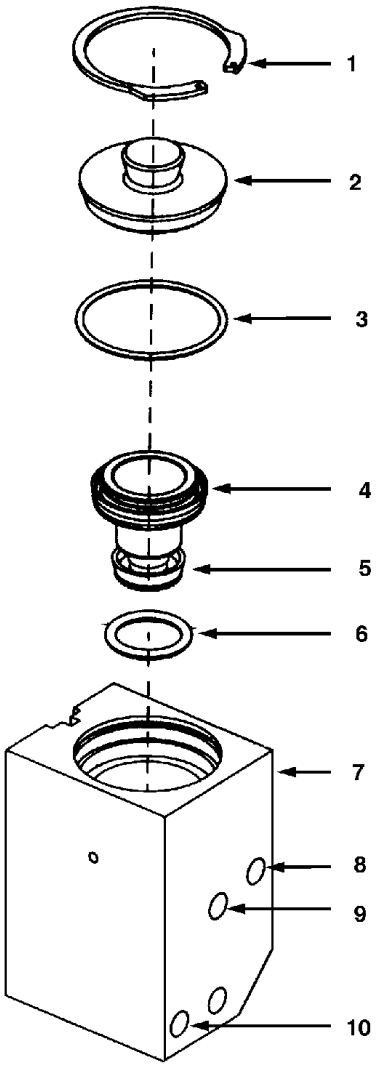
### Removing the GIV assembly

2. Use the 3 mm hex wrench to loosen the two (2) captive inlet valve mounting screws.
3. Lift the inlet valve/solenoid switch assembly out of the ventilator chassis.
4. Examine the seat and O-rings in the manifold for damage. Replace as necessary.

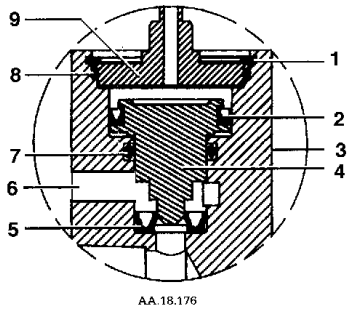
### Removing the solenoid switch

Use a 1.5 mm hex wrench to remove the mounting screws from the solenoid switch on the inlet valve.

## 6.8. Gas Inlet Valve Repair




1. Retaining ring
2. Valve cap
3. O-ring
4. Shuttle with upper U-cup
5 Lower U-cup
6. O-ring
7. Inlet valve housing
8. Captive mounting screw
9. Gas inlet port
10. Captive mounting screw




**Cross section view**

1. Retaining ring
2. U-cup seal, upper
3. Valve housing
4. Shuttle body
5. U-cup seal, lower
6. Inlet port (access to remove shuttle)
7. O-ring, lower
8. O-ring, upper
9. Valve cap

**Figure 6-28**
Gas inlet valve exploded view

1. Remove the retaining ring and valve cap.
2. Remove the shuttle and replace the first O-ring and U-cup seal. Lubricate the seal with KRYTOX™.

   To remove the shuttle you'll need a pen light and small flat blade screwdriver.

   a. Remove the retaining ring and valve cap as in step 1.

   b. Push the shuttle fully into the housing with your finger and use the

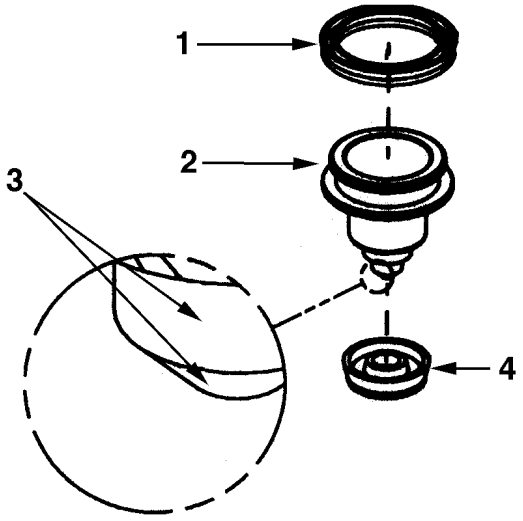
pen-light to look into the gas inlet port (See cross section view, item 6). You should see a shoulder of the shuttle.

**CAUTION:** ⚠ **Do not push hard against the shoulder. Do not use an object that has a sharp or pointed end to lift the shuttle. The sealing area of the shuttle may be damaged.**

c. Insert the screwdriver into the inlet port and very gently lift the shuttle toward the opening. While looking at the top opening of the valve, you will see the top of the shuttle move up.

d. Look into the port again and you will see another shoulder. Repeat step c, **but be very careful**. A slight scratch or nick on this area of the shuttle will cause an unacceptable leak.

e. Use your fingers to remove the shuttle for U-cup and lower O-ring replacement.

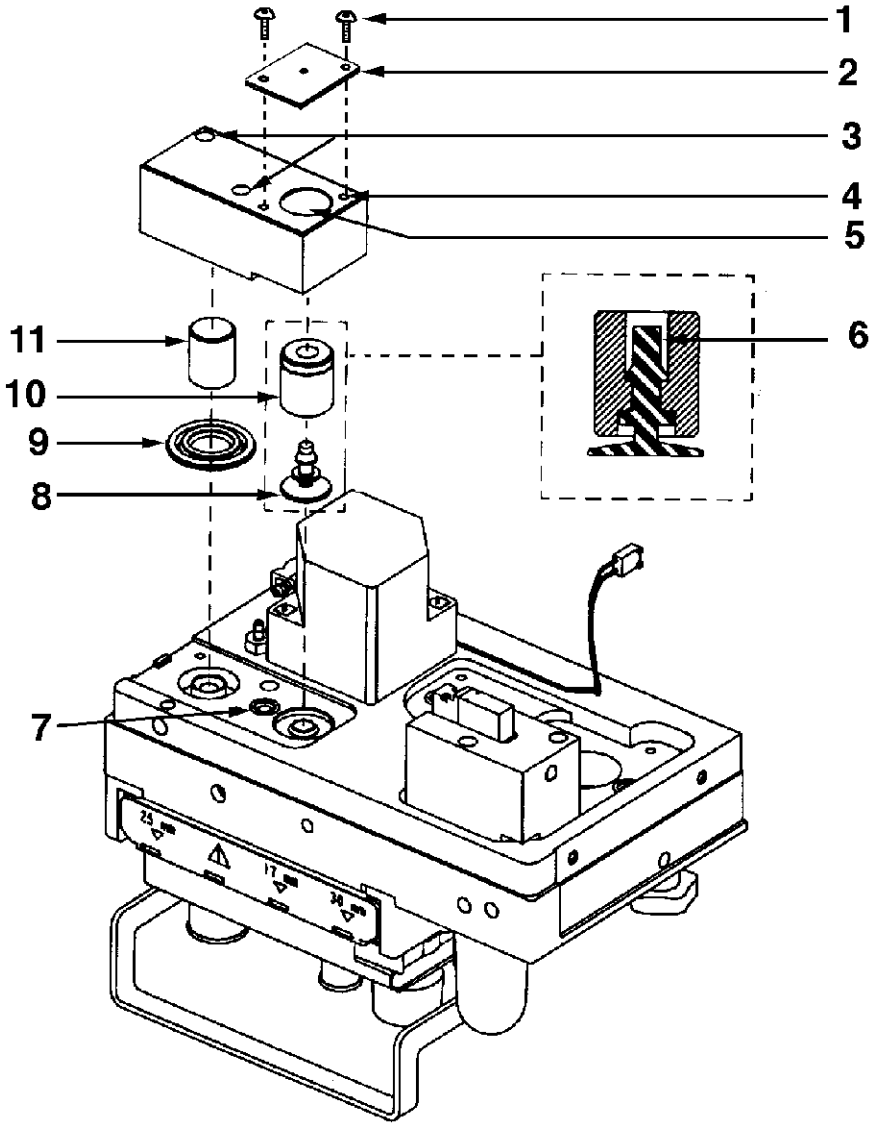



1. **U-cup seal, upper**
2. **Shuttle**
3. **Apply KRYTOX**
4. **U-cup seal, lower**

**Figure 6-29**
Detail shuttle and U-cup seals

3. Replace the second O-ring and second U-cup seal. Lubricate the O-ring and seal with KRYTOX™.
4. Reinstall the shuttle.
5. Replace and lubricate the first O-ring as you install the inlet valve cap.
6. Install the retaining ring flat side out (away from the block).

## Removing the Mechanical Over-pressure Bleed Off valve (MOBO) assembly




1. **Cover screws M4 x 8 button head**
2. **No-pilot weight cover**
3. **Captive MOBO mounting screws**
4. **Threaded for cover screws**
5. **Cylinder hole for alignment tool and no-pilot weight**
6. **No pilot weight and pressure seal.**
7. **Port with O-ring**
8. **Pressure seal for no-pilot weight**
9. **Diaphragm for pilot weight**
10. **No-pilot weight**
11. **Pilot weight**

**Figure 6-30**
Mechanical Over-pressure Bleed Off valve (MOBO) removal

## MOBO removal (See figure 6-30)

1. Use the 3 mm hex wrench to loosen the two (2) captive mounting screws holding the MOBO body (item 2) to the pneumatic manifold.
2. Lift off the MOBO housing from the manifold. Weights will remain on the manifold.
3. Lift the pilot weight (item 11) and the diaphragm (item 9) off the manifold. (Discard the pilot weight if it does not match the weight in the elastomers kit.)
4. Lift off the no-pilot weight assembly (items 8 and 10).
5. Inspect the pressure seal of the no-pilot weight and the diaphragm, item 9. Replace as necessary. If replacing the diaphragm, ensure that you install the pilot weight and diaphragm in the elastomers kit.
6. Item 6 of figure 6-30 is a cross-sectional view of the no-pilot weight, showing the proper installation of the pressure seal. The seal must be pulled through the weight and the top trimmed below the top surface.

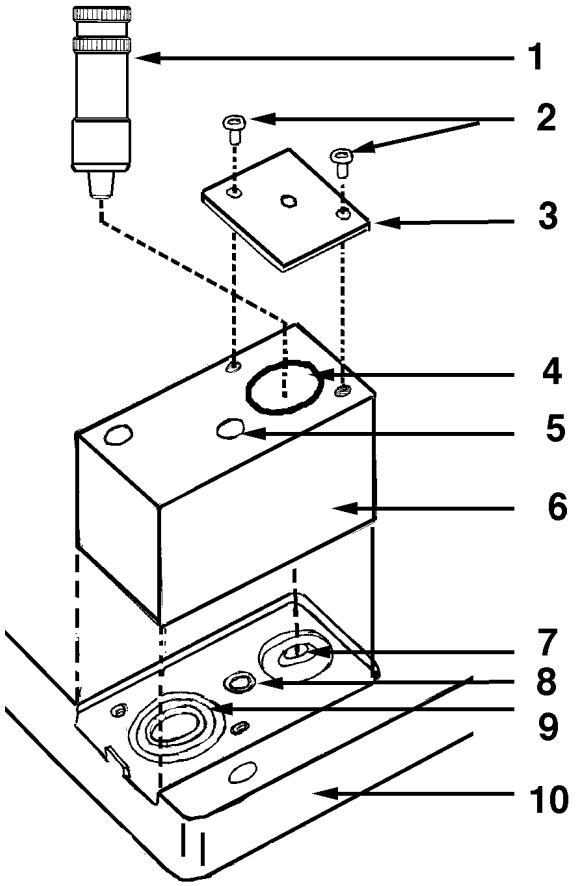
## MOBO installation and low pressure operation check

1. Remove the bellows and the pop-off valve from the ABA and reinstall the ABA housing.
2. Connect the ventilator to the anesthesia machine for normal operation with the APL switch set to VENT.
3. Occlude the "Y" piece of the patient breathing circuit.
4. Place the diaphragm and pilot weight onto the manifold.

**Note**: When replacing the diaphragm, also replace the pilot weight included in the elastomer kit.

5. Set the valve housing into the recessed area on the main manifold.
6. Align the side of the housing along the back edge of the manifold so it is parallel and equal spaced.
7. Remove the MOBO top cover mounting screws with a 2.5 mm hex wrench and remove the cover.
8. Inset the alignment tool (item 1, figure 6-31) into the hole (item 4, figure 6-31) exposed when the top cover was removed in step 2.
9. Use a 3 mm hex wrench and gently start the threads of the captive mounting screws. See item 5, figure 6-31. Tighten just enough to hold the assembly but loose enough so the assembly housing may be moved about on the manifold.
10. Set fresh gas flow to 3 L/min.
11. Occlude the waste gas scavenging port on the exhalation manifold.
12. Observe the circuit pressure gauge on the absorber. Swivel the MOBO housing around the alignment tool until the pressure reads 20 to 40 cm $H_2O$.
13. Tighten the captive housing mounting screws and verify that the circuit pressure remains within the allowable range.
14. Remove the alignment tool and install the high pressure (no pilot) weight.

15. Install the MOBO housing cover.
16. Reinstall the bellows and ABA pop-off valve, the ABA housing and remove all occlusions.

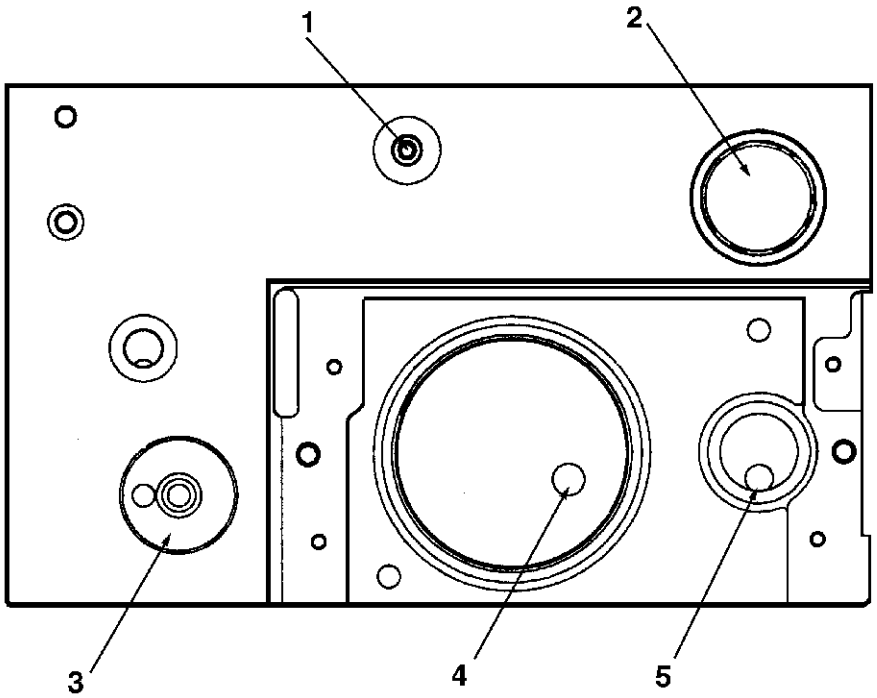



1. **MOBO installation alignment tool**
2. **Cover mounting screws, 4x8 mm**
3. **Top cover, no-pilot weight cylinder**
4. **No-pilot weight cylinder**
5. **Captive MOBO assembly mounting screws**
6. **MOBO assembly body**
7. **Port for no-pilot weight**
8. **Port with O-ring**
9. **Port for pilot weight diaphragm**
10. **7900 main manifold**

**Figure 6-31**
MOBO alignment and installation

## Mechanically cycle MOBO weights (See figure 6-30)

1. Check to ensure smooth operation of the MOBO weights by lifting them mechanically. Remove the exhalation manifold to gain access. Use a blunt object to push the weights up and then allow them to drop back down. See figure 6-32.

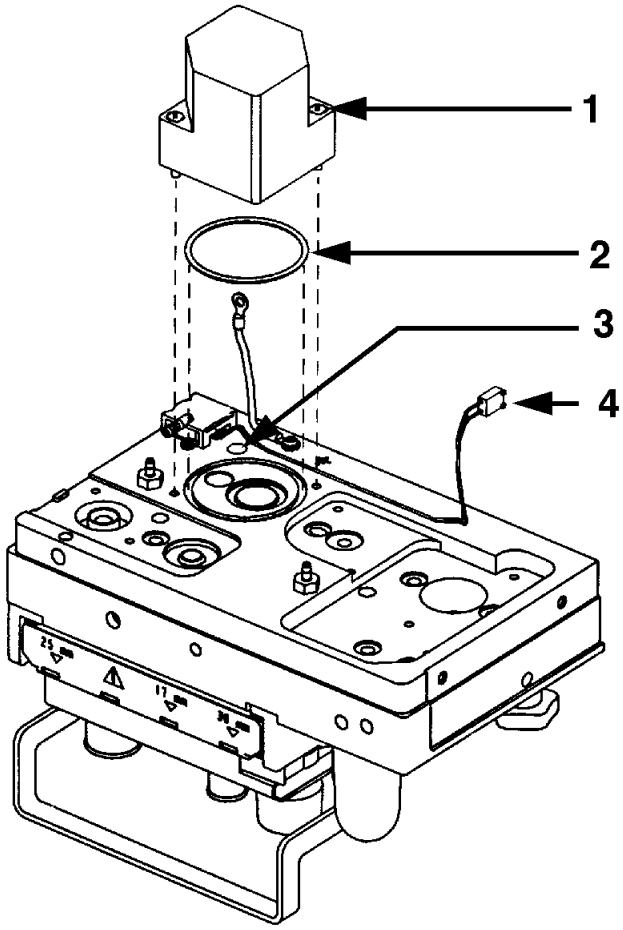



1. **Regulated pressure check port**
2. **Free breathing valve**
3. **Supply gas filter bowl**
4. **Access to MOBO weight, no pilot**
5. **Access to MOBO weight pilot**

**Figure 6-32**
Main manifold bottom view, exhalation manifold removed

**CAUTION:** ⚠ **Do not use an object that has a sharp or pointed end to lift the weights. The seals may be damaged.**

### Removing the Drive gas check valve assembly



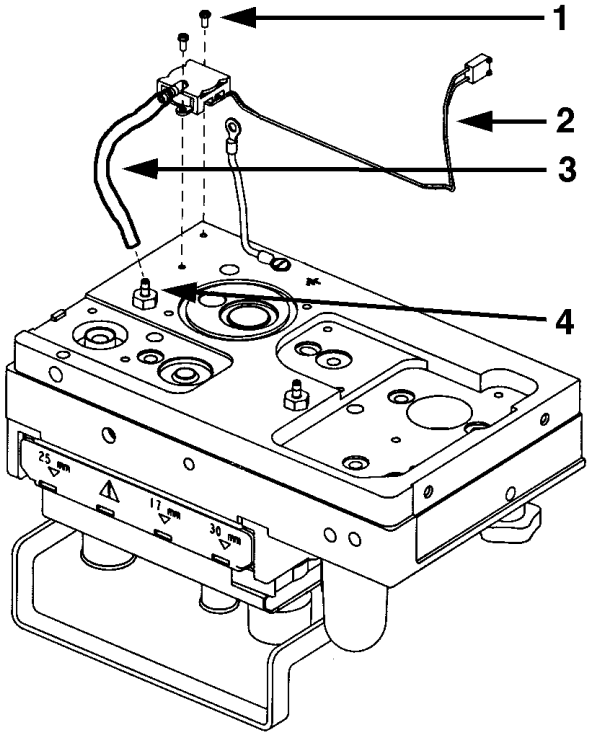

1. **Captive mounting screws**
2. **O-ring**
3. **Alignment hole**
4. **Pressure switch harness**

**Figure 6-33**
Drive gas check valve removal

**CAUTION** ⚠ **The internal components of the Drive Gas Check Valve are precisely positioned. Do not attempt to remove or reposition the glass sleeve or piston assembly.**

1. Use a 3 mm hex wrench to loosen the drive gas check valve captive mounting screws.
2. Lift out the valve assembly.
3. Inspect the O-ring and seat for damage. Replace as necessary.
4. When installing the valve, do not pinch the pressure harness, item 2.
5. Align check valve pin into the alignment hole in the manifold for proper orientation.
6. Tighten the captive screws.

## Removing the pressure sensing switch assembly



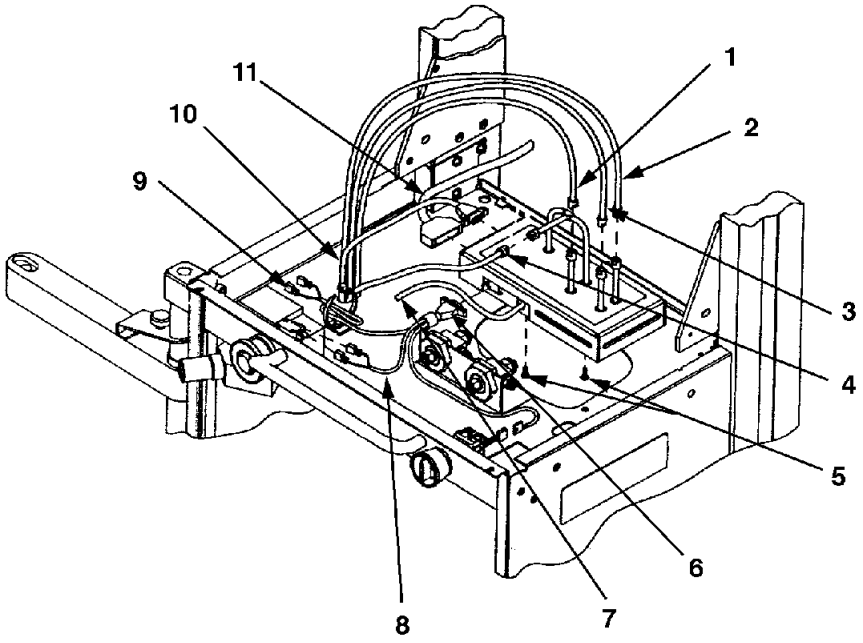

1. **Pressure switch mounting screws**
2. **Cable connector to microcontroller board J8**
3. **Pneumatic tube to main manifold**
4. **Main manifold/pressure switch pneumatic connection**

**Figure 6-34**
Pressure sensing switch removal

1. Disconnect the cable connector, J8, from the microcontroller board.
2. Disconnect the hose (item 4) from the manifold to the pressure sensing switch.
3. Use the 2 mm hex wrench to remove the pressure switch mounting screws (item 5).

**CAUTION:** ⚠ **Do not disconnect the hoses while the SIB is under pressure. This may damage the SIB components. Ensure the flow transducers are not pressurized by removing the breathing circuit before disconnecting any of the SIB interconnecting hoses.**

## 6.9. SIB Removal from Excel/Modulus SE




1. **Black color coded pneumatic hose, interface panel (expiratory flow sensor) to SIB**
2. **Yellow color coded pneumatic hose, interface panel (inspiratory flow sensor) to SIB**
3. **Blue color coded pneumatic hose from interface panel (expiratory flow sensor) to SIB**
4. **Natural color coded pneumatic hose, interface panel (inspiratory flow sensor) to SIB**

**SIB assembly**

5. **SIB assembly mounting screws**
6. **Machine interface harness to SIB J3**
7. **Pneumatic tubing from O2 supply to sense/detect $O_2$ failure**
8. **Cable connection to $O_2$ flush valve**
9. **French units only. Cable to DCO select switch**
10. **Cable from sensor interface panel to SIB J1***
11. **Cable from ventilator to SIB J2**

• Interface panel mounting may vary depending on machine configuration.

**Figure 6-35**
SIB assembly cable and pneumatic hose identification (Excel 210SE shown)

The SIB mounts under the gas machine's work surface in the component compartment area.

1. The SIB is replaced as an assembly and is shipped as a replacement part with cable connectors and quick connect, color coded, hose fittings for the pneumatic hoses that attach between it and the interface.
2. The flow sensors have two pneumatic hose connections and an electronic cable connection each. The hose connections are color coded so connections between the interface panel on the gas machine and the SIB are easily made.
3. The cable also connects the $O_2$ sensor to the SIB.
4. The SIB has another cable that goes out the back of the gas machine to the ventilator and connects to a cable connector on the 7900 ventilator chassis bottom.

## SIB (Sensor Interface Board) Assembly Removal

1. Set the SE System Master Switch to OFF.
2. Disconnect Oxygen pipeline hose and close Oxygen cylinders. Depress the Oxygen Flush valve to relieve residual pressure.
3. Unplug the system AC power cord from the AC source.
4. Remove the Table top from the SE. See Excel SE Service Manual, section 5.1, Modulus SE Service Manual Section 5.3.

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**CAUTION:** ⚠ **Do not disconnect the hoses while the SIB is under pressure. This may damage the SIB components. Ensure the flow transducers are not pressurized by removing the breathing circuit before disconnecting any of the SIB interconnecting hoses.**

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5. Disconnect the four color coded tubing connectors (items 1-4 Figure 6-35) from the SIB Assembly tubing.
6. Disconnect connector J1 from P1 on the SIB Assembly (item 10, Figure 6-35).
7. Disconnect connector J2 from P2 on the SIB Assembly (item 11, Figure 6-35).
8. Disconnect connector J3 from P3 on the SIB Assembly (item 6, Figure 6-35)
9. Disconnect the O2 tubing from the SIB Assembly (item 7, Figure 6-35).
10. If applicable, remove all gas cylinders
11. Open the Vanity panel on the rear of the Anesthesia Machine
12. If applicable, remove any monitor from the shelf or slide the drawer open to access the SIB mounting screws on the underside of the pan.
13. Remove the two mounting screws (Note: On machines that had the 7900 retrofitted in the field, the SIB is mounted to a plate. The Mounting Plate mounting screws are forward of the mounting screws shown in Figure 6-35, at the two forward corners of the plate. The SIB is attached to the mounting plate with two screws that are in the same location as shown in Figure 6-35).
14. Carefully slide the SIB assembly forward until the transducer connections clear the gauge panel. Remove the assembly from the pan.

## Replacement Calibration Instructions (SIB):

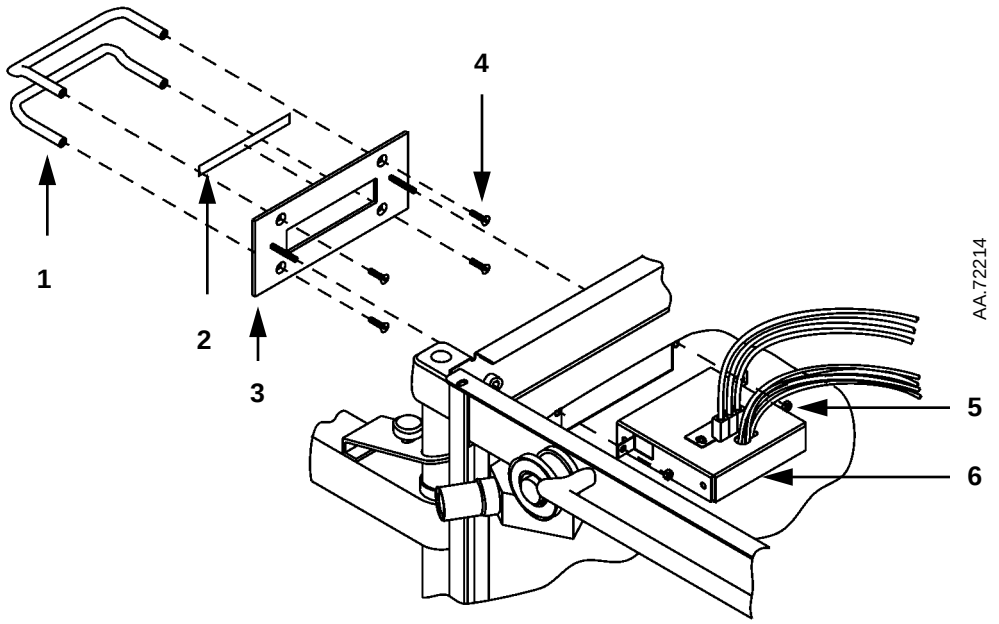
If the SIB must be replaced, follow the "Replacement Calibration Instructions" for the Microcontroller Board. See "Removing Microcontroller circuit board" at the beginning of this section. Prior to placing the system in operation, all procedures in section 4 and the preoperative checkout must be completed.

**CAUTION:** ⚠ **Do not disconnect the hoses while the SIB is under pressure. This may damage the SIB components. Ensure the flow transducers are not pressurized by removing the breathing circuit before disconnecting any of the SIB interconnecting hoses.**

# 6.10 Patient Interface Harness Removal from Excel SE

**Note**: The Patient Interface Panel/Harness is replaced as an assembly which includes the flow transducer connectors, oxygen sensor connector, interface harness, transducer tubing with color coded connectors and housing.

1. Set the SE System Master Switch to OFF.
2. Unplug the system AC power cord from the AC source.
3. Disconnect the Inspiratory and Expiratory Flow Transducers from the Interface Panel.
4. Disconnect the Oxygen Sensor Harness from the Interface Panel.
5. Remove the Tabletop from the Excel SE. See Excel SE Service Manual section 5.1.
6. Disconnect the four color coded tubing connectors from the SIB Assembly tubing.
7. Carefully cut and remove cable ties that secure the electrical harness to the pan.
8. Disconnect connector J1 form P1 on the SIB Assembly.
9. While supporting the Interface Assembly, remove the two M4 keps nuts (item 5, Figure 6-36) using a 7 mm nutdriver.
10. Carefully route the harness and tubing through the pan to remove the assembly.




1. **Handle, sensor interface, 1002-3952-000 (2)**
2. **Label, patient interface, 1001-3464-000**
3. **Panel, sensor interface 210, 1002-3970-000**
4. **Screw, # 10-32 x 3/8, 0140-6231-106 (4)**
5. **Nut, keps M4, 0144-3717-314 (2)**
6. **Harness, SA, SIB, 1503-3081-000**

**Figure 6-36**
Patient interface/harness assembly (shown mounted on Excel 210 SE left side)

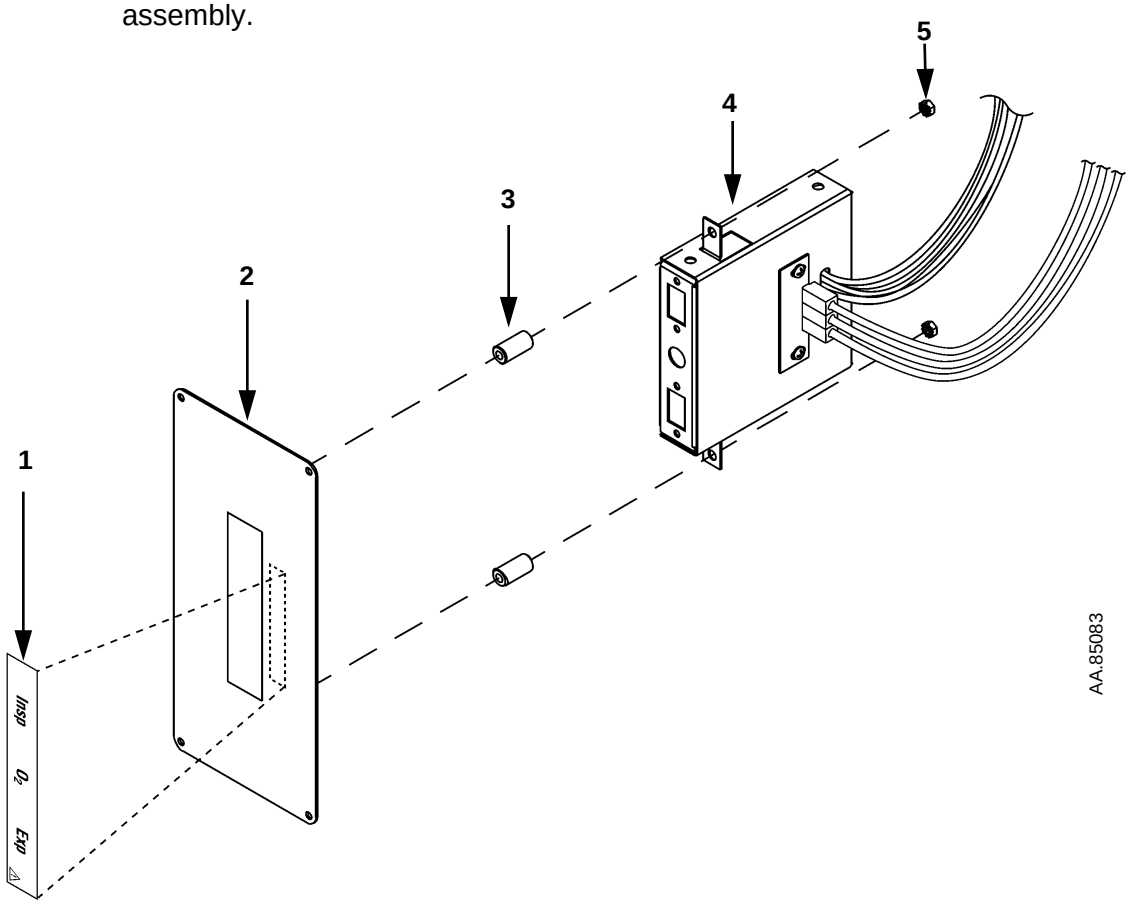
**CAUTION:** ⚠ **Do not disconnect the hoses while the SIB is under pressure. This may damage the SIB components. Ensure the flow transducers are not pressurized by removing the breathing circuit before disconnecting any of the SIB interconnecting hoses.**

## 6.11 Patient Interface Panel/Harness Assembly Removal From Modulus SE

Note: The Patient Interface Panel/Harness is replaced as an assembly which includes the flow transducer connectors, oxygen sensor connector, interface harness, transducer tubing with color coded connectors and housing.

1. Set the SE System Master Switch to OFF.
2. Unplug the system AC power cord from the AC source.
3. Disconnect the Inspiratory and Expiratory Flow Transducers from the Interface Panel.
4. Disconnect the Oxygen Sensor Harness from the Interface Panel.

5. Remove the Tabletop from the Modulus SE. See Modulus SE Service Manual section 5.3.
6. Disconnect the four color coded tubing connectors from the SIB Assembly tubing.
7. Carefully cut and remove the cable ties that secure the electrical harness to the pan.
8. Disconnect connector J1 from P1 on the SIB Assembly.
9. Open the Vanity panel on the rear of the Anesthesia Machine.
10. While supporting the Interface Assembly, remove the two M4 keps nuts (item 5, Figure 6-37) using a 7 mm nutdriver.
11. Carefully route the harness and tubing through the pan to remove the assembly.




1. **Label, patient interface, 1001-3464-000**
2. **Harness SA, SIB, 1503-3081-000**
3. **Panel, sensor interface, Modulus SE, 1004-3933-000**
4. **Spacer, sensor interface panel, 1004-3934-000 (2)**
5. **Nut, keps M4, 0144-3717-314 (2)**

**Figure AA.85.083**
Patient Interface/Harness Assembly (shown mounted on the Modulus SE left side)

## 6.12. SIB/Machine Interface Harness Removal

1. Set the SE System Master Switch to OFF.
2. Unplug the system AC power cord from the AC source.
3. Remove the Tabletop from the SE. See Excel Service Manual section 5.1, Modulus SE Service Manual section 5.3.
4. Refer to Figure 6-35.
5. Disconnect connector J3 from P3 on the SIB Assembly.
6. Remove the two faston connections and the ground wire from the Oxygen Flush microswitch.
7. If applicable, remove the two faston connections and the ground wire from the DCGO microswitch.
8. Disconnect the harness from the System Master Switch.
9. Carefully cut and remove the cable ties that secure the electrical harness to the pan.

## 6.13. Test unit after repair as follows

1. Connect the gas supply hose.
2. Connect the cable from the ventilator to the SIB board and the RS232 serial port connection (if applicable).
3. Plug the ventilator power cord into the gas machine electrical box.

   The unit should now operate external of the gas machine using the gas machine ON/STANDBY switch for ventilator power.
4. Perform Post Service Checkout, Section 3.

# 7/ Illustrated Parts List

## 7.1. General

The following illustrations are shown in a disassembled form for easier illustration of parts as they are disassembled. The 7900 Ventilator has a pneumatic section and an electronic section. They are separated by a barrier with a gasket to keep pneumatic gasses from leaking over into the electronic section.

At the end of this section is a page with the heading "Notes". This page is placed intentionally for your convenience.

### Special Instructions

Apply a thin coat of oxygen-use-approved lubricant to O-rings prior to installation (unless otherwise noted). Use:

KRYTOX™ GPL 205, Ohmeda Stock Number — 1001-3854-000

Some screws require an anti-loosening bond. Use:

Loctite #24231, screw lock, Ohmeda Stock Number — 0220-5016-300

When replacing fittings, position the barb end in the same direction as the original fitting to make hose connections easier.

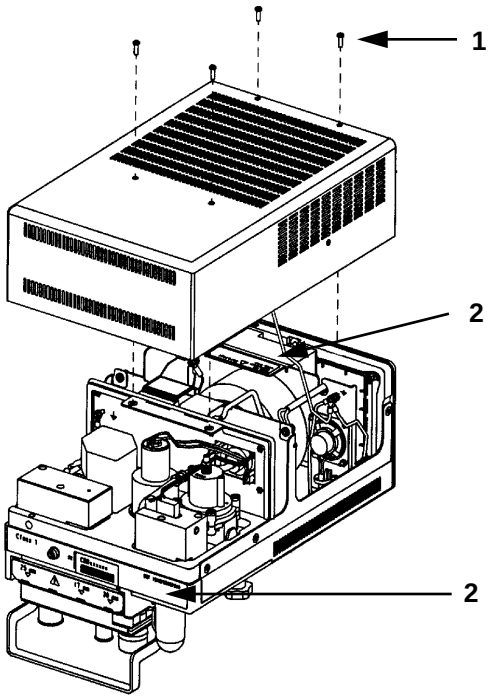
### Stock Numbers for Replacement Parts

Stock Numbers are identified in the /Illustrated Parts List following.

## 7.2. 7900 SERVICE KITS:

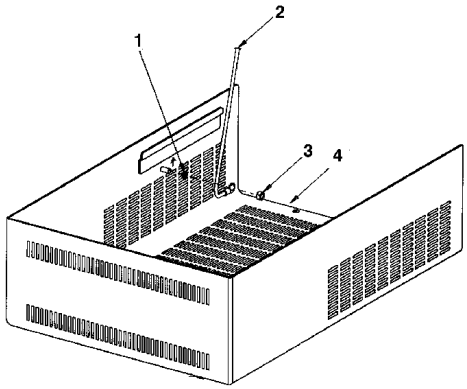
See section 09 Appendix for further detail and other parts not shown in this section.

| Description | Part number |
|---|---|
| Stand Assembly Service | 1503-8005-000 |
| Kit IC Programmed U30 and U40 Rev. 2.4 | 1503-8015-000 |
| Kit PC Assembly Microcontroller Svc | 1503-8007-000 |
| Kit PC Assembly Power Supply Svc | 1503-8008-000 |
| Kit PC Assembly SIB Svc<br>Includes calibrated SIB assembly) | 1503-8009-000 |
| Kit EL Display | 1503-8010-000 |
| Kit Manifold Main Svc | 1503-8011-000 |
| Kit Valve Flow Control Svc | 1503-8013-000 |
| Kit Latch assembly Service 7900 Vent | 1503-8014-000 |
| Kit, Cable Software Upgrade, Service 7900 Vent | 1503-8019-000 |




1. **Screw M4, 0140-6226-111 (4)**
2. **Label set, 1503-3027-000 (includes fuse label on bottom chassis)**

**Figure 7-1**
Top cover




1. **Washer, 9213-0540-003**
2. **Ground wire, 1500-7037-000**
3. **Hex nut, 0144-3717-314,**
4. **Top cover, 1503-3031-000**

**Figure 7-2**
Top cover ground wire connections

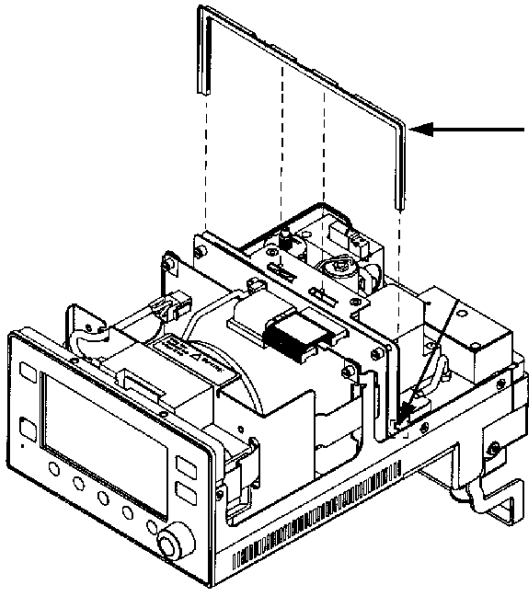
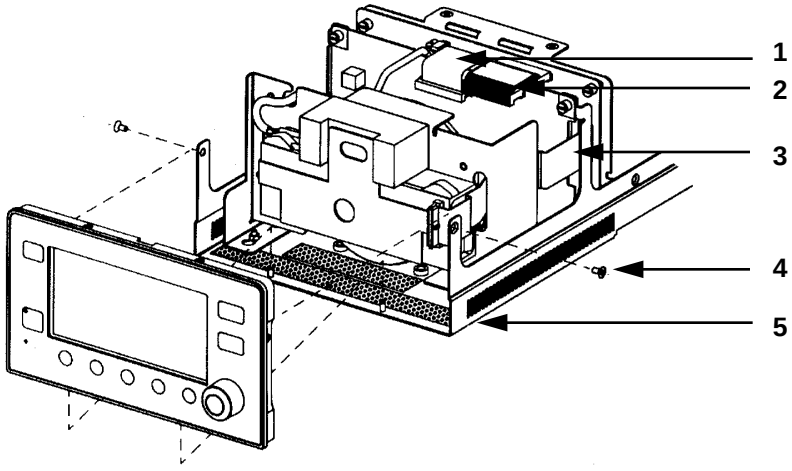
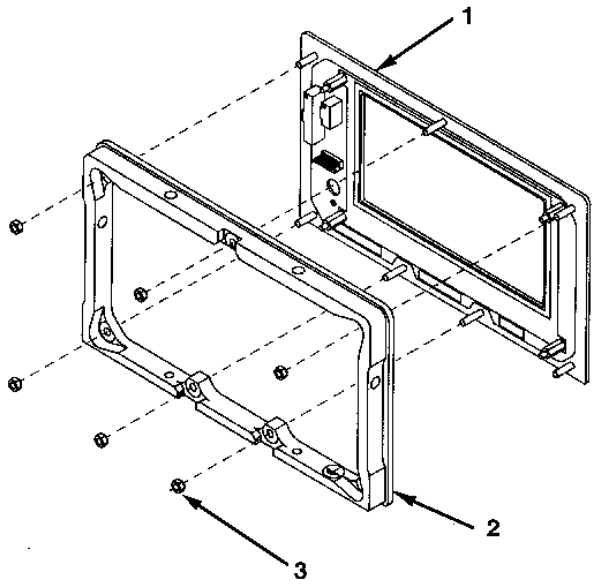


**Figure 7-3**
Isolation barrier gasket, 1503-3018-000



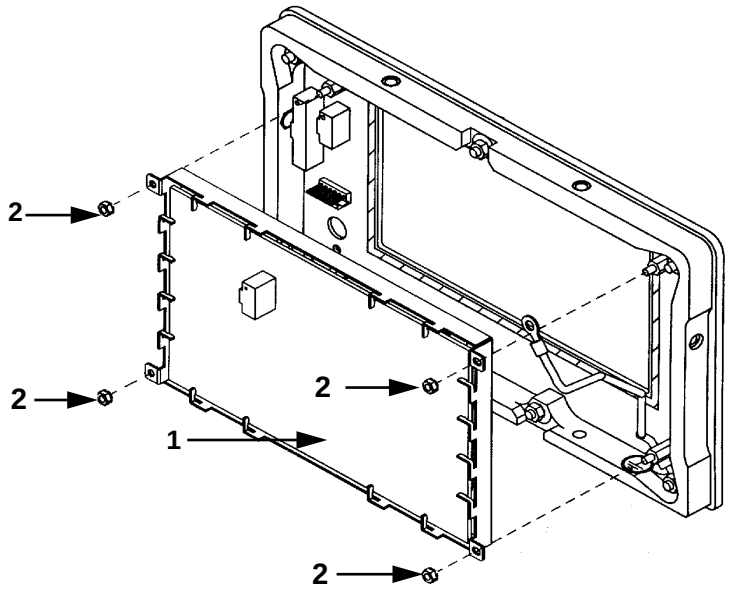

1. **Signal harness, 1503-3054-000**
2. **DC power harness, 1503-3053-000**
3. **Keyboard/microboard harness, 1503-3052-000**
4. **Screw M4 x 8, 1503-3135-000**
5. **Main chassis, 1503-3040-000**

**Figure 7-4**
Front panel assembly mounting and harnesses



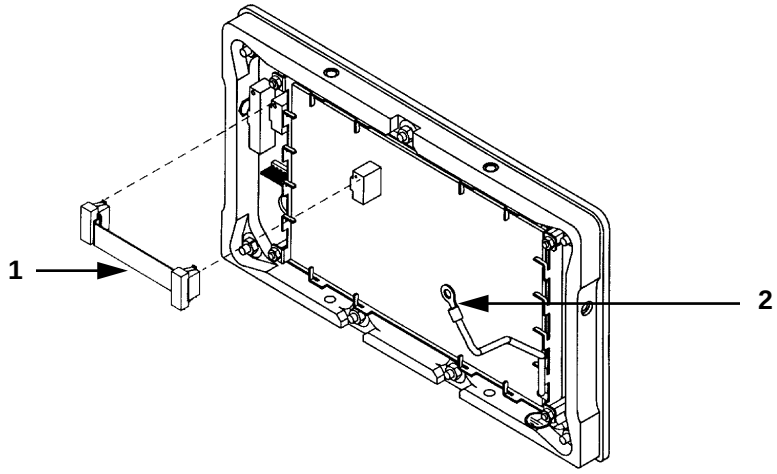

1. **Key board, front panel, 1503-3010-000**
2. **Bezel, 1503-5001-000**
3. **Keps nuts M4, 0144-3717-314 (6)**

**Figure 7-5**
Front panel key board and bezel




1. **EL display kit, 1503-8010-000**
2. **Keps nut M3, 0144-3717-302 (4)**

**Figure 7-6**
EL display panel mounting



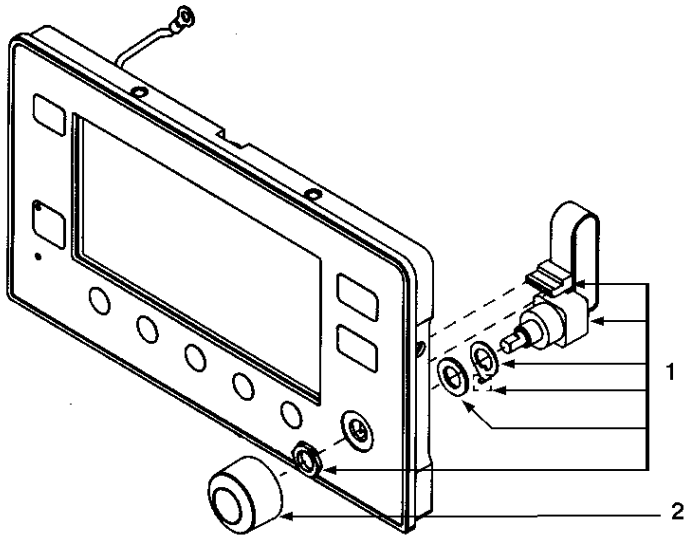

1. **Harness display/keyboard, 1503-3051-000**
2. **Ground harness, 1500-7048-000**

**2a. Keps nut M4 (not shown), 0144-3717-314 (2)**

**2b. Washer M4 (not shown), 9213-0540-003 (2)**

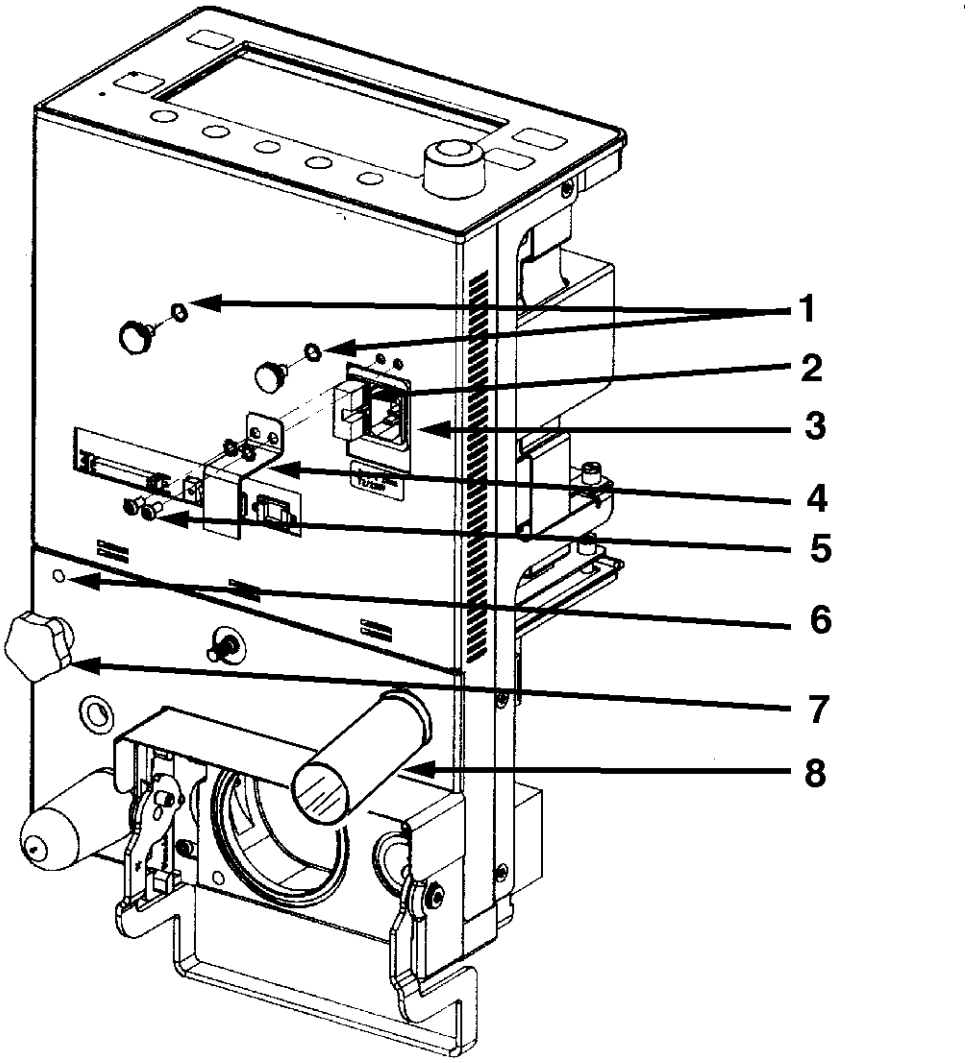
3. **Keyboard/microboard harness (not shown), 1503-3052-000**

**Figure 7-7**
Front panel display assembly harnesses



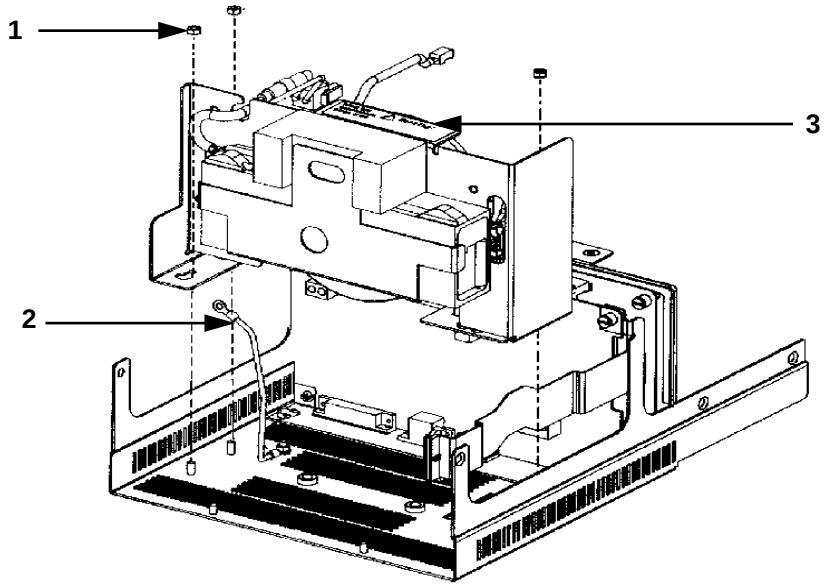

1. **Rotary encoder, 1503-3012-000 includes all parts except the knob**
2. **Knob,1503-3030-000**

**Figure 7-8**
Encoder, rotary, 16 position with push button switch.




1. **Mounting shelf locating pins for anesthesia system, 1503-5013-000**
2. **Power cord fuse block, 1503-3020-000. See figure 7-11**
3. **Power cord receptacle, see Figure 7-11**
4. **Power cord bracket, 1503-3070-000**
5. **Bracket mounting screws, 0140-6226-118 (2), lockwashers 9213-0540-003 (2)**
6. **Threaded hole for shipping screw**
7. **Locking knob, 1301-3018-000**
8. **Deflector tube for free breathing valve, 1503-3110-000**
9. **Power cord (not shown)**
   **ANSI - 1503-3078-000**
   **IEC - 1503-3079-000**
   **REV IEC - 1503-3080-000**

**Figure 7-9**
Chassis bottom view

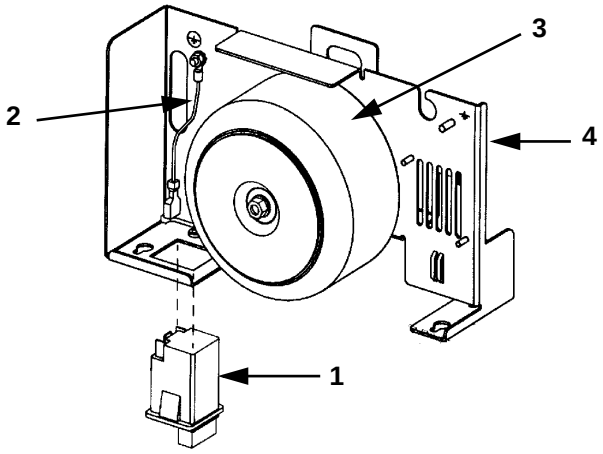



1. **Keps nut M4, 0144-3717-314 (3)**
2. **Ground harness, 1500-7048-000**

**2a. Keps nut (not shown), 0144-3717-314 (2)**
**2b. Washer M4 (not shown), 9213-0540-003 (2)**

3. **Label set, 1503-3027-000**

**Figure 7-10**
Power module mounting




1. **Connector, AC inlet 1503-3000-000**

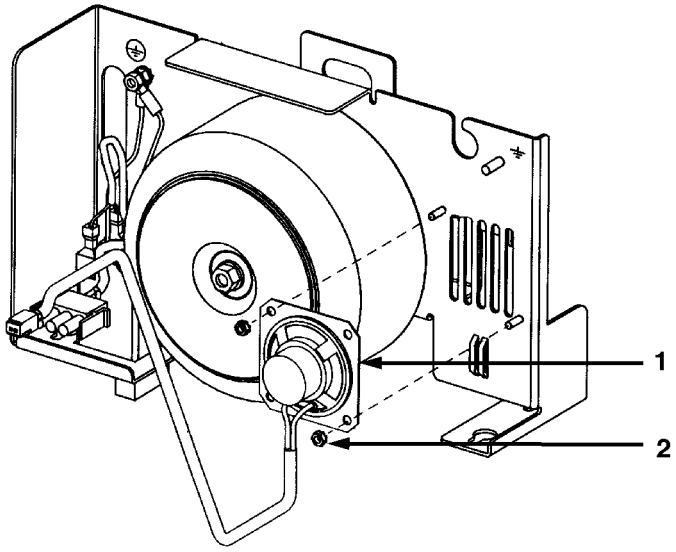
**1a. Fuse 2 amp 250V 5x20 mm delayed time (not shown), 1503-3073-000 (2)**

2. **Filter harness, 1500-7053-000**

**2a. Keps nut M4 (not shown), 0144-3717-314**
**2b. Washer M4 (not shown), 9213-0540-003**

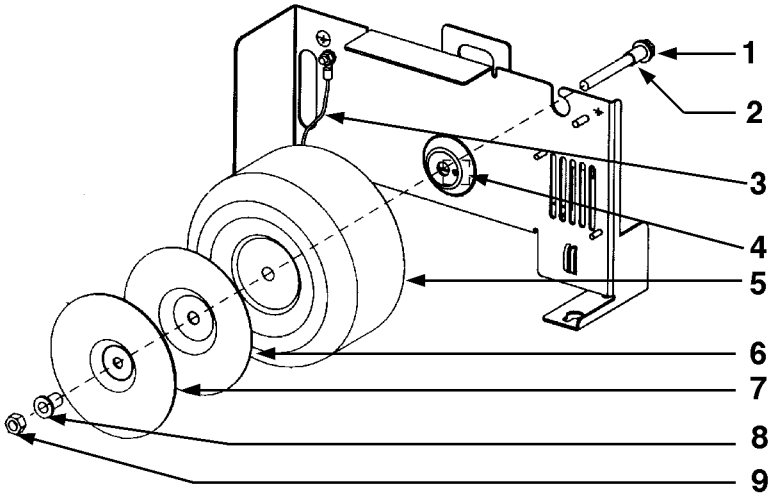
3. **Transformer assembly, 1503-3017-000, see Figure 7-13**
4. **Bracket power module, 1503-3060-000**

**Figure 7-11**
Power module components




1. **Speaker, 1503-3106-000**
2. **Keps- nut, M3, 0144-3717-302 (2)**

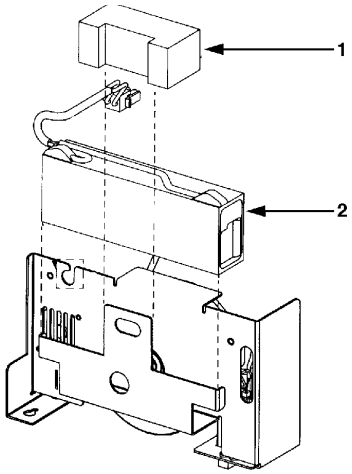
**Figure 7-12**
Alarm speaker




Parts 1 through 9 are included with the transformer under part number 1503-3017-000.

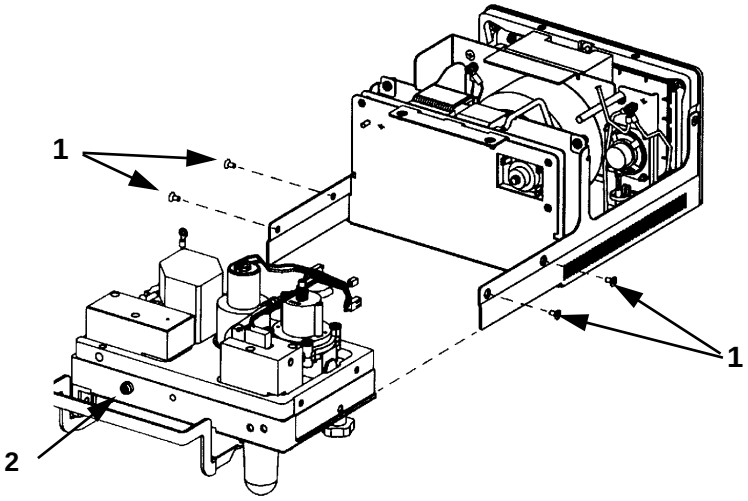
1. **Bolt**
2. **Nylon sleeve**
3. **Ground wire**
4. **Mounting location notch**
5. **Transformer coil**
6. **Rubber insulator**
7. **Mounting plate**
8. **Nylon sleeve**
9. **Hex nut, locking**

**Figure 7-13**
Transformer assembly (exploded view)




1. **Foam retainer block, 1503-3021-000**
2. **12 Volt battery with harness, 1503-3045-000.**
3. **Battery fuse, 4 amp inline, 1503-3074-000 (not shown) supplied with battery**

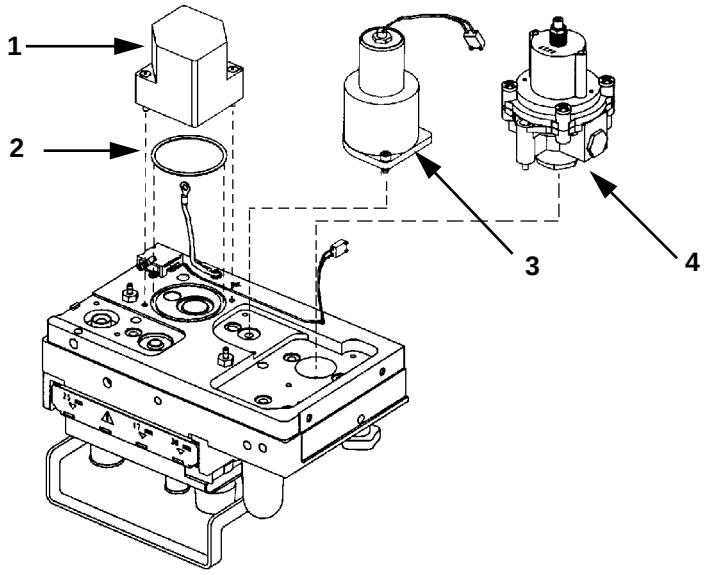
**Figure 7-14**
Battery




1. **Screw M4 x 8, 1503-3135-000 (4)**
2. **Bleed orifice, 1503-5003-000**

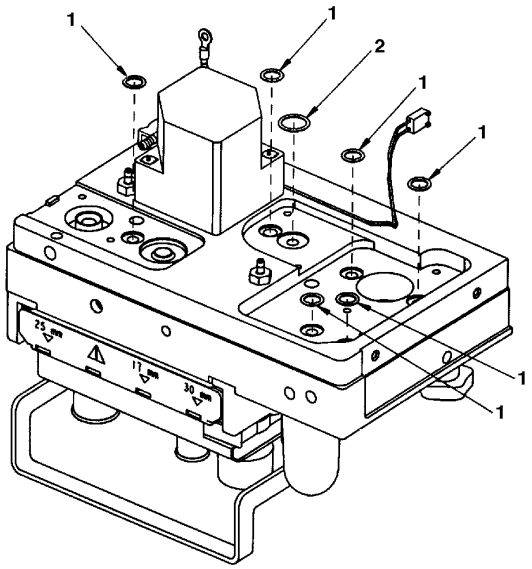
2a. **O-ring (not shown), 0210-0547-300**

**Figure 7-15**
Pneumatic manifold mounting



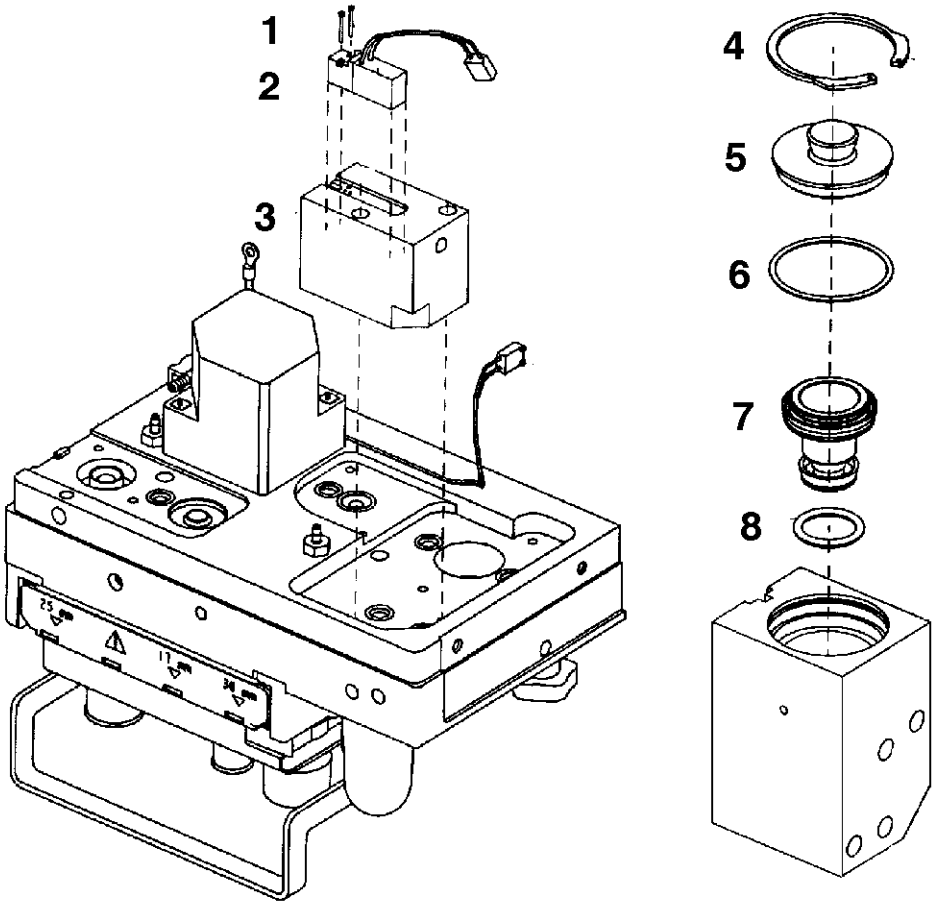

1. **Drive gas check valve assembly 1503-3006-000**
2. **O-ring - 1503-3057-000**
3. **Flow control valve, 1503-8013-000**
4. **Regulator, 1503-3004-000**

**Figure 7-16**
Manifold components




1. **O-rings, 1503-3056-000 (6)**
2. **O-ring, 0210-0538-300 (1)**

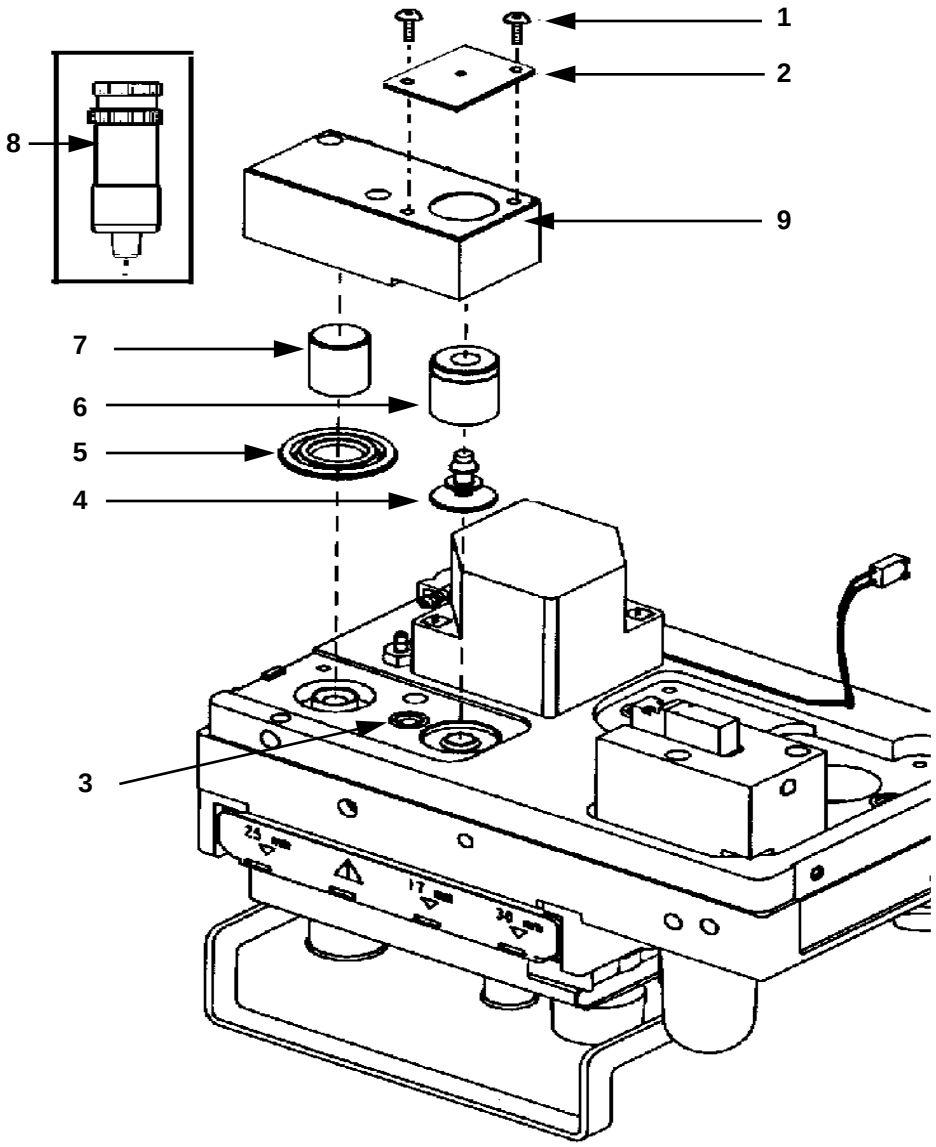
**Figure 7-17**
Pneumatic manifold O-rings




1. **Solenoid mounting screws, included with solenoid**
2. **Solenoid, 1503-3088-000**
3. **Gas inlet valve body, 1503-8012-000***
4. **Retaining ring, 1500-3158-000**
5. **GIV cap, 1503-5006-000**
6. **O-ring, 32.1 ID 35.3 OD, 9221-3032-116**
7. **GIV shuttle with U-cups**
   **Suttle (poppet), 1503-5018-000**
   **U-cup (upper) 26.98 OD 20.63 ID,1503-3090-000**
   **U-cup (lower)17.02 OD 5.33 ID,1503-3089-000**
8. **O-ring, 15.6 ID 20.4 OD Vito1503-3108-000**

*** Includes mounting screws 1503-3105-000 (2)**

**Figure 7-18**
Gas inlet valve

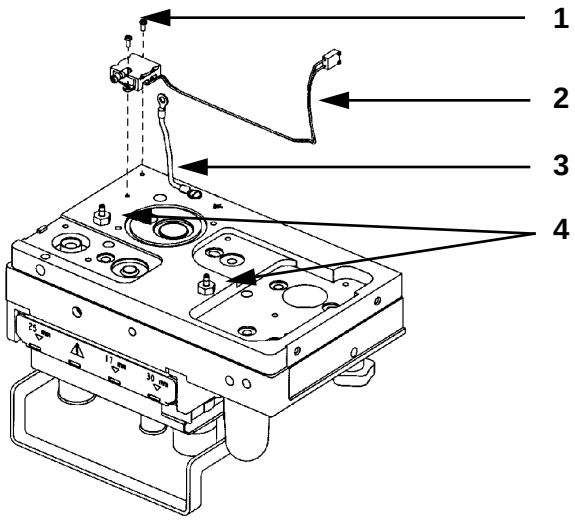



1. **Screw M4, 9211-0640-083 (2)**
2. **Alignment hole cover, 1503-3122-000**
3. **O-ring, 1503-3056-000**
4. **Seal pressure valve*†**
5. **Diaphragm MOBO†**
6. **Weight, no pilot, 1503-5015-000**
7. **Weight, pilot, 1503-5014-000†**
8. **Installation alignment tool, 1503-3124-000†**
9. **Housing MOBV, 1503-5016-000,**
   **mounting screw (not shown) 1503-3105-000 (2)**

* **Installation alignment tool must be used when replacing seal**

† **Included in elastomers service kit, 1503-8017-000. When replacing diaphram, pilot weight must also be replaced.**

**Figure 7-19**
MOBO (Mechanical Over-pressure Bleed Off) valve



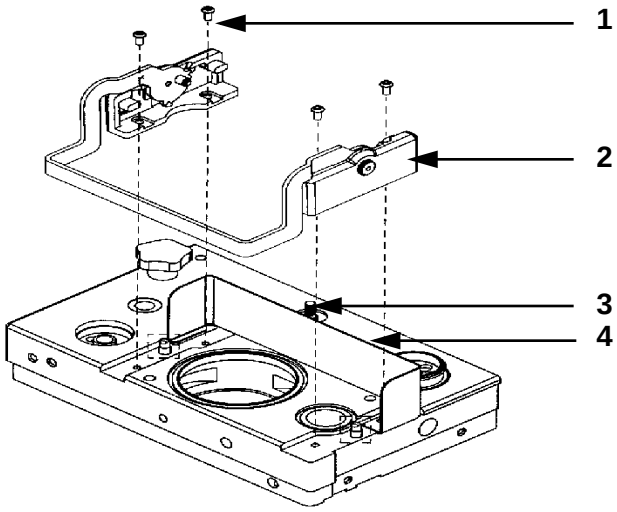

1. **Screw M3 x 6, 9211-0430-063 (2)**
2. **Pressure switch, 1503-3023-000**
3. **Ground harness, 1500-7049-000**

**3a. Screw M4 (not shown), 0140-6226-118**
**3b. Washer M4 (not shown),9213-0540-003 (3)**
**3c. Keps nut M4 (not shown), 0144-3717-314**

4. **Fitting with o-ring, 1503-3007-000 (2)**
5. **Tubing (not shown), 0994-6370-010 (90 mm long 2 pieces)**

**5a. Coupling (not shown) 1503-3026-000**

**Figure 7-20**
Manifold components (continued)

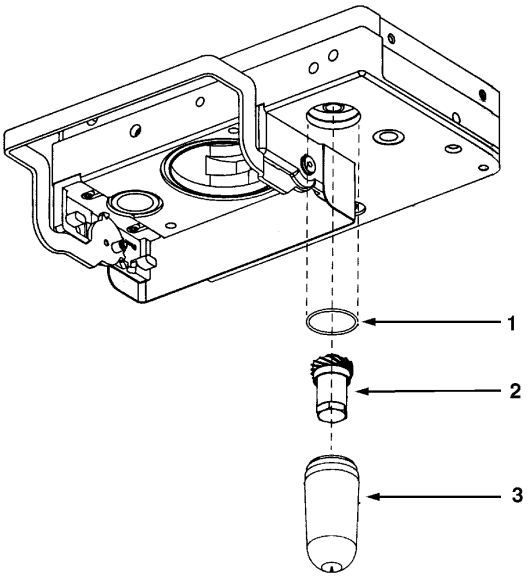



1. **Screw M4 x 8 button head, 0140-6226-118**
2. **Latch assembly service kit, 1503-8014-000**

**2a. Not shown, guide springs included, 1503-3029-000**

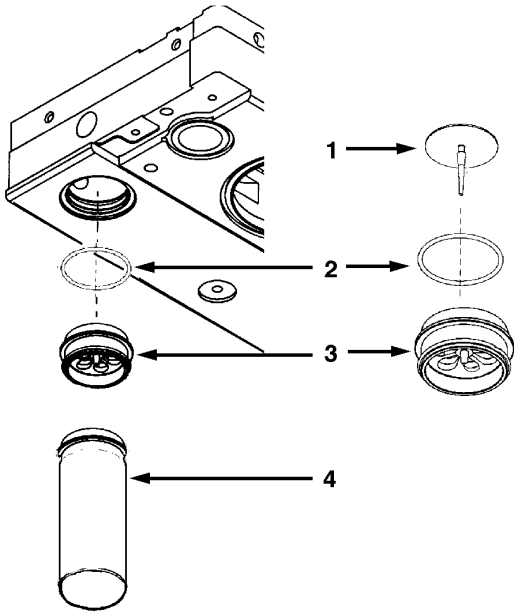
3. **Test plug, 0213-4728-300**
4. **O2 deflector shield, 1503-3109-000**

**Figure 7-21**
Exhalation manifold latch assembly



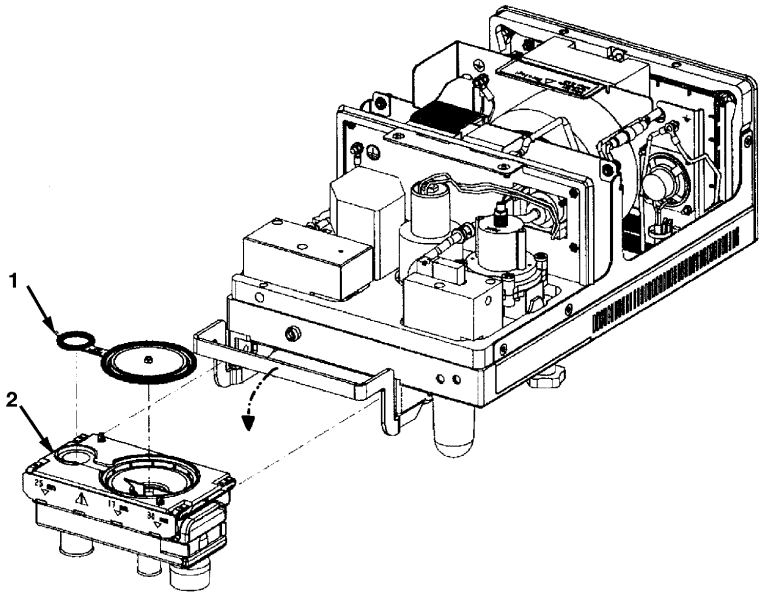

1. **O-ring**
2. **Filter element**
3. **Filter bowl**
4. **Service Kits - O-rings and filter element, 1500-3320-000**
   **- Replacement kit complete filter assembly, 1500-3319-000**

**Figure 7-22**
Supply gas filter assembly, see O & M Manual




1. **Valve flapper, 0211-1454-100**
2. **O-ring, 1503-3034-000**
3. **Check valve seat, 0207-5590-100**
4. **Tube, oxygen deflector, 1503-3110-000**

**Figure 7-23**
Free breathing valve




1. **Diaphragm assembly, 1503-3000-000**
2. **Exhalation valve assembly, 1503-3001-000**
3. **Exhalation valve kit (not shown) includes 2 diaphragms, 2 o-rings, gasket and manifold assembly,1503-8004-000**

**Figure 7-24**
Exhalation manifold valve, see O&M Manual

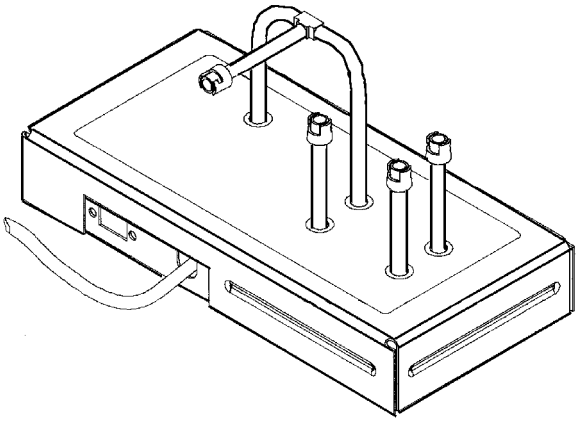


**Figure 7-25**
SIB (Sensor interface board) assembly, 1503-8009-000

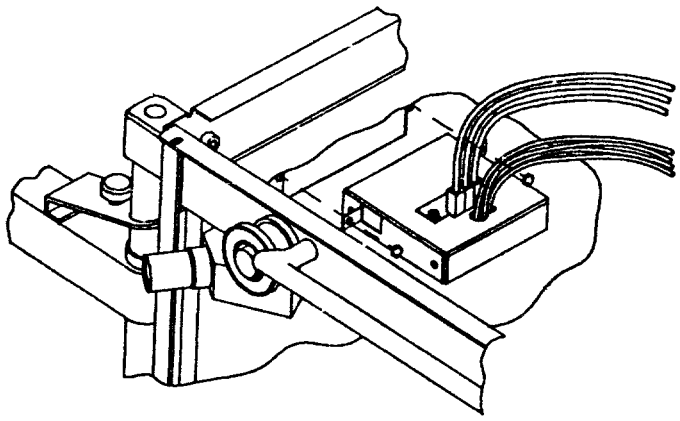


**Figure 7-26**
Patient interface board assembly, 1503-3081-000, (includes harness, interface panel and tubing)

## SIB Harnesses

SIB/Machine interface harness, 1503-3082-000 (connects $O_2$ flush, system ON/ Standby and DCGO on French machines).

SIB/7900 Ventilator cable, 1503-3075-000 (connects between the SIB and Ventilator).

Serial interface cable, 7900/RGM, 1503-3076-000.

Serial Interface cable, 1503-3077-000 (connects between the ventilator and RS-232 device).

# 8 /Schematics

Schematics are subject to change without notice.

Circuit boards are available only as complete assemblies.


Figure 8-1 System connection block diagram . . . . . 8-2
Figure 8-2 SIB schematic diagram interface cable connections . . . . . 8-3
Figure 8-3 Patient interface cable - Machine side. . . . . 8-4
Figure 8-4 SIB interface, hose and cable routing. . . . . 8-5
Figure 8-5 7900 SIB schematic diagram, page 1 of 2 . . . . . 8-6
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Figure 8-7 Microcontroller board schematic diagram, page 1 of 10. . . . . 8-8
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Figure 8-10 Microcontroller board schematic diagram, page 4 of 10. . . . . 8-11
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Figure 8-19 Power supply board schematic diagram, page 3 of 5. . . . . 8-20
Figure 8-20 Power supply board schematic diagram, page 4 of 5. . . . . 8-21
Figure 8-21 Power supply board schematic diagram, page 5 of 5. . . . . 8-22


These symbols reference supply common.

A = Analog Ground

D = Digital Ground

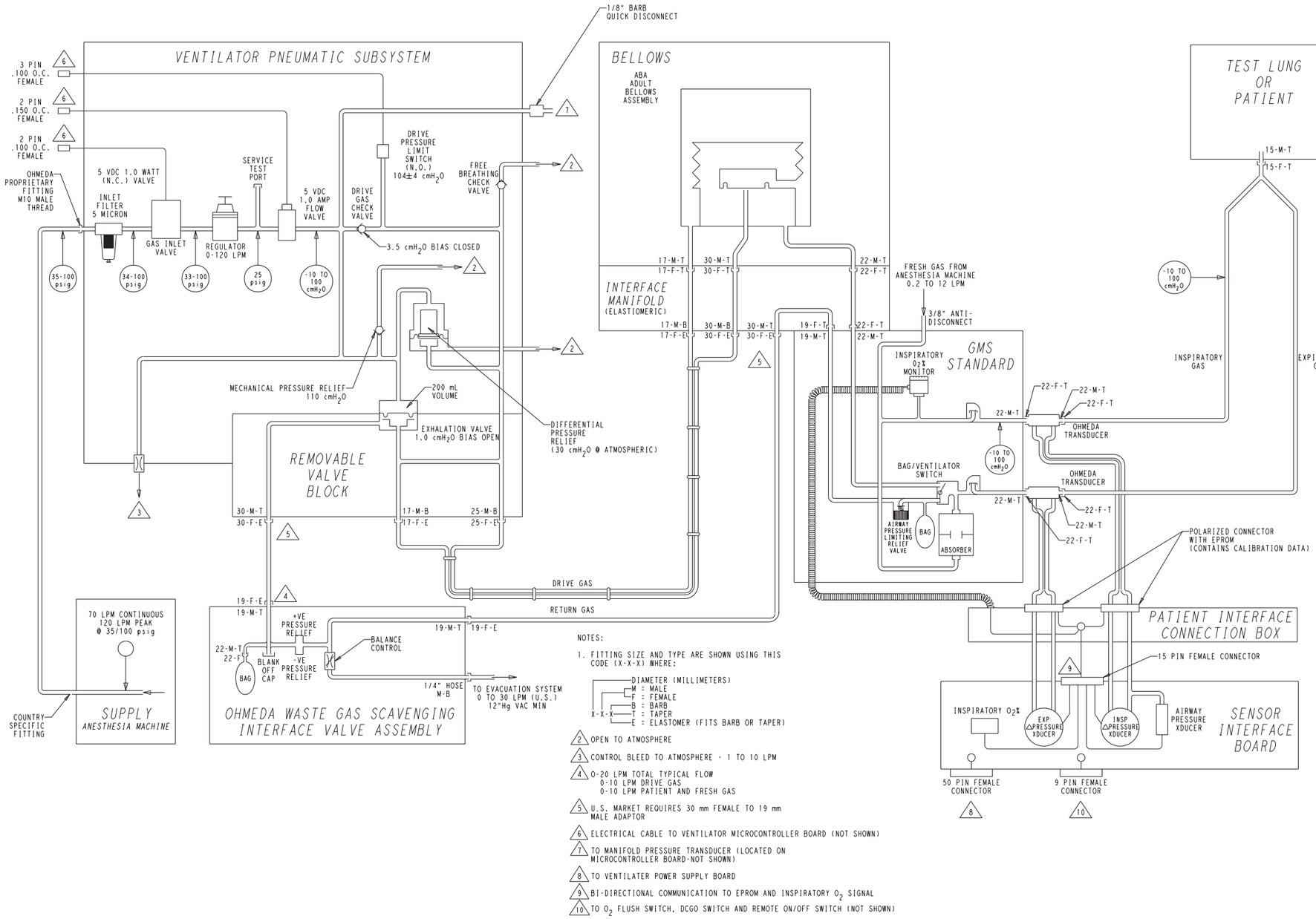

VENTILATOR PNEUMATIC SUBSYSTEM
BELLOWS
ABA ADULT BELLOWS ASSEMBLY
TEST LUNG OR PATIENT
1/8" BARB QUICK DISCONNECT
3 PIN .100 O.C. FEMALE
2 PIN .150 O.C. FEMALE
2 PIN .100 O.C. FEMALE
OHMEDA PROPRIETARY FITTING M10 MALE THREAD
5 VDC 1.0 WATT (N.C.) VALVE
INLET FILTER .5 MICRON
GAS INLET VALVE
SERVICE TEST PORT
REGULATOR 0-120 LPM
5 VDC 1.0 AMP FLOW VALVE
DRIVE GAS CHECK VALVE
DRIVE PRESSURE LIMIT SWITCH (N.O.) 104±4 cmH2O
FREE BREATHING CHECK VALVE
3.5 cmH2O BIAS CLOSED
35-100 psig
34-100 psig
33-100 psig
25 psig
-10 TO 100 cmH2O
MECHANICAL PRESSURE RELIEF 110 cmH2O
200 mL VOLUME
EXHALATION VALVE 1.0 cmH2O BIAS OPEN
DIFFERENTIAL PRESSURE RELIEF (30 cmH2O @ ATMOSPHERIC)
REMOVABLE VALVE BLOCK
DRIVE GAS
RETURN GAS
INTERFACE MANIFOLD (ELASTIOMERIC)
FRESH GAS FROM ANESTHESIA MACHINE 0.2 TO 12 LPM
3/8" ANTI-DISCONNECT
GMS STANDARD
INSPIRATORY O2% MONITOR
OHMEDA TRANSDUCER
BAG/VENTILATOR SWITCH
AIRWAY PRESSURE LIMITING RELIEF VALVE
BAG
ABSORBER
INSPIRATORY GAS
EXPIRATORY GAS
POLARIZED CONNECTOR WITH EPROM (CONTAINS CALIBRATION DATA)
PATIENT INTERFACE CONNECTION BOX
15 PIN FEMALE CONNECTOR
INSPIRATORY O2%
EXP ΔPRESSURE XDUCER
INSP ΔPRESSURE XDUCER
AIRWAY PRESSURE XDUCER
SENSOR INTERFACE BOARD
50 PIN FEMALE CONNECTOR
9 PIN FEMALE CONNECTOR
70 LPM CONTINUOUS 120 LPM PEAK @ 35/100 psig
COUNTRY SPECIFIC FITTING
SUPPLY ANESTHESIA MACHINE
+VE PRESSURE RELIEF
BALANCE CONTROL
BLANK OFF CAP
-VE PRESSURE RELIEF
1/4" HOSE M-B
TO EVACUATION SYSTEM 0 TO 30 LPM (U.S.) 12"Hg VAC MIN
OHMEDA WASTE GAS SCAVENGING INTERFACE VALVE ASSEMBLY
NOTES:
1. FITTING SIZE AND TYPE ARE SHOWN USING THIS CODE (X-X-X) WHERE:
DIAMETER (MILLIMETERS)
M = MALE
F = FEMALE
B = BARB
T = TAPER
E = ELASTOMER (FITS BARB OR TAPER)
2 OPEN TO ATMOSPHERE
3 CONTROL BLEED TO ATMOSPHERE - 1 TO 10 LPM
4 0-20 LPM TOTAL TYPICAL FLOW 0-10 LPM DRIVE GAS 0-10 LPM PATIENT AND FRESH GAS
5 U.S. MARKET REQUIRES 30 mm FEMALE TO 19 mm MALE ADAPTOR
6 ELECTRICAL CABLE TO VENTILATOR MICROCONTROLLER BOARD (NOT SHOWN)
7 TO MANIFOLD PRESSURE TRANSDUCER (LOCATED ON MICROCONTROLLER BOARD-NOT SHOWN)
8 TO VENTILATER POWER SUPPLY BOARD
9 BI-DIRECTIONAL COMMUNICATION TO EPROM AND INSPIRATORY O2 SIGNAL
10 TO O2 FLUSH SWITCH, DCGO SWITCH AND REMOTE ON/OFF SWITCH (NOT SHOWN)

**Figure 8-1**
System connection block diagram

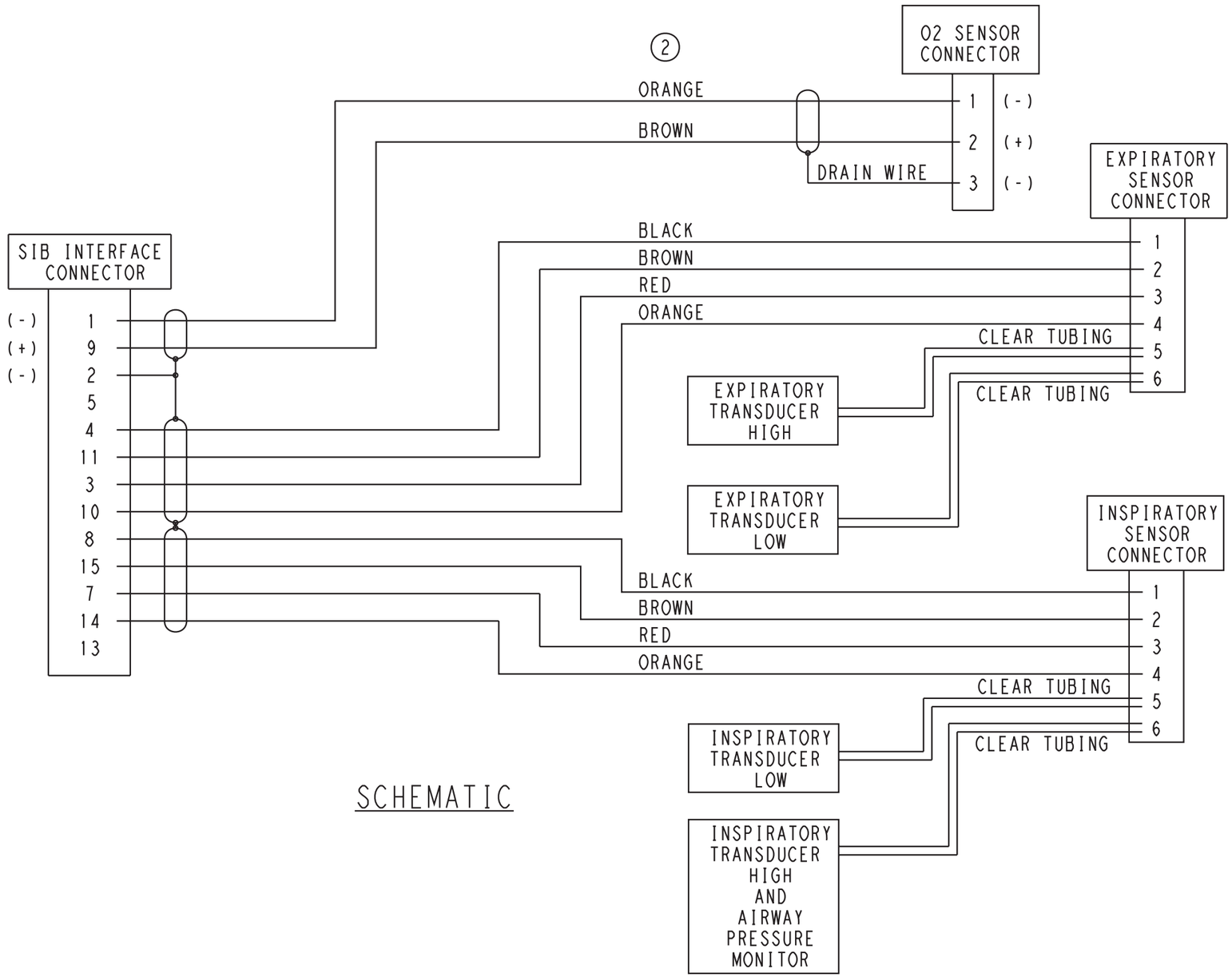



**Figure 8-2**
SIB schematic diagram interface cable connections

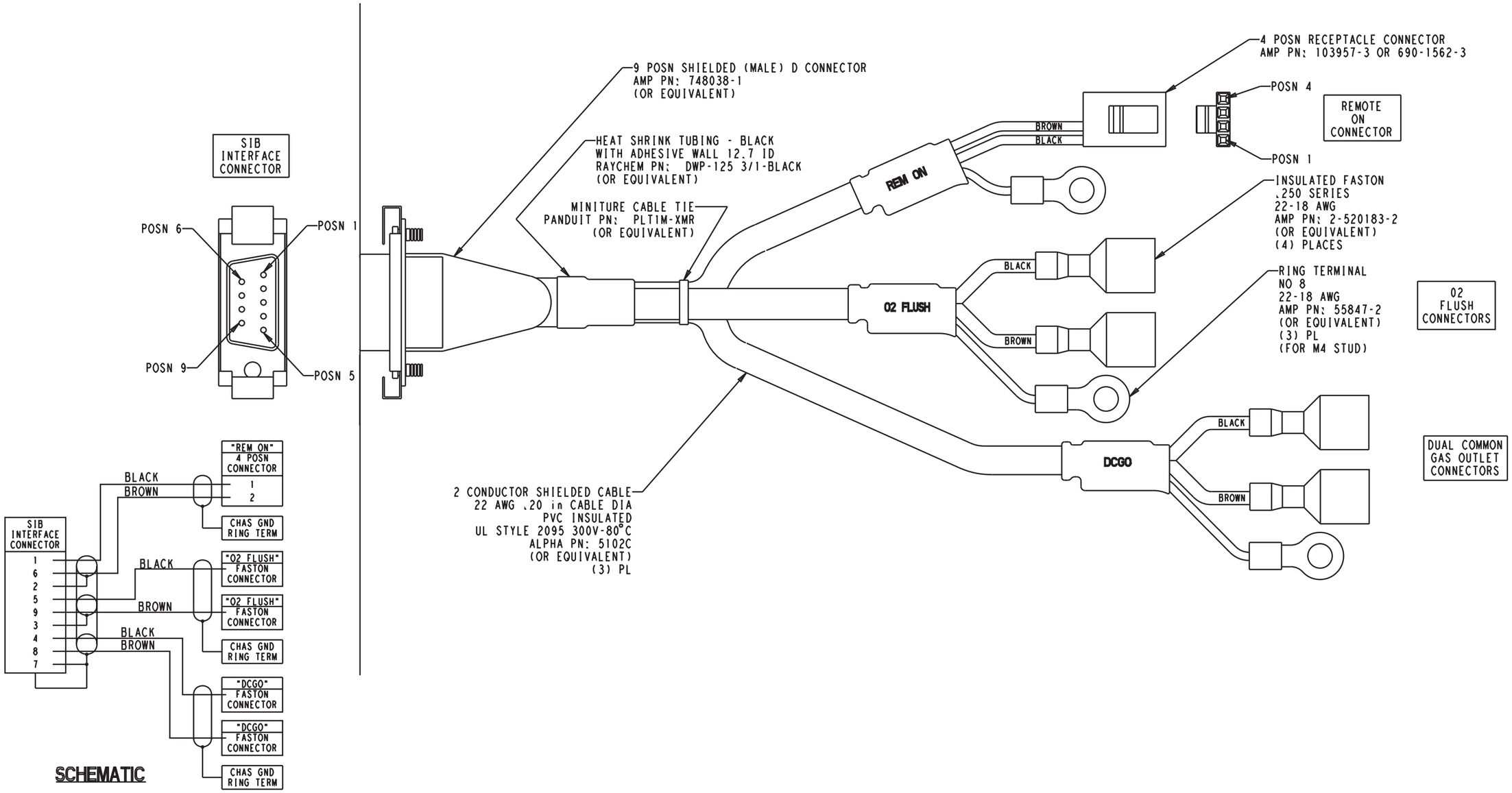
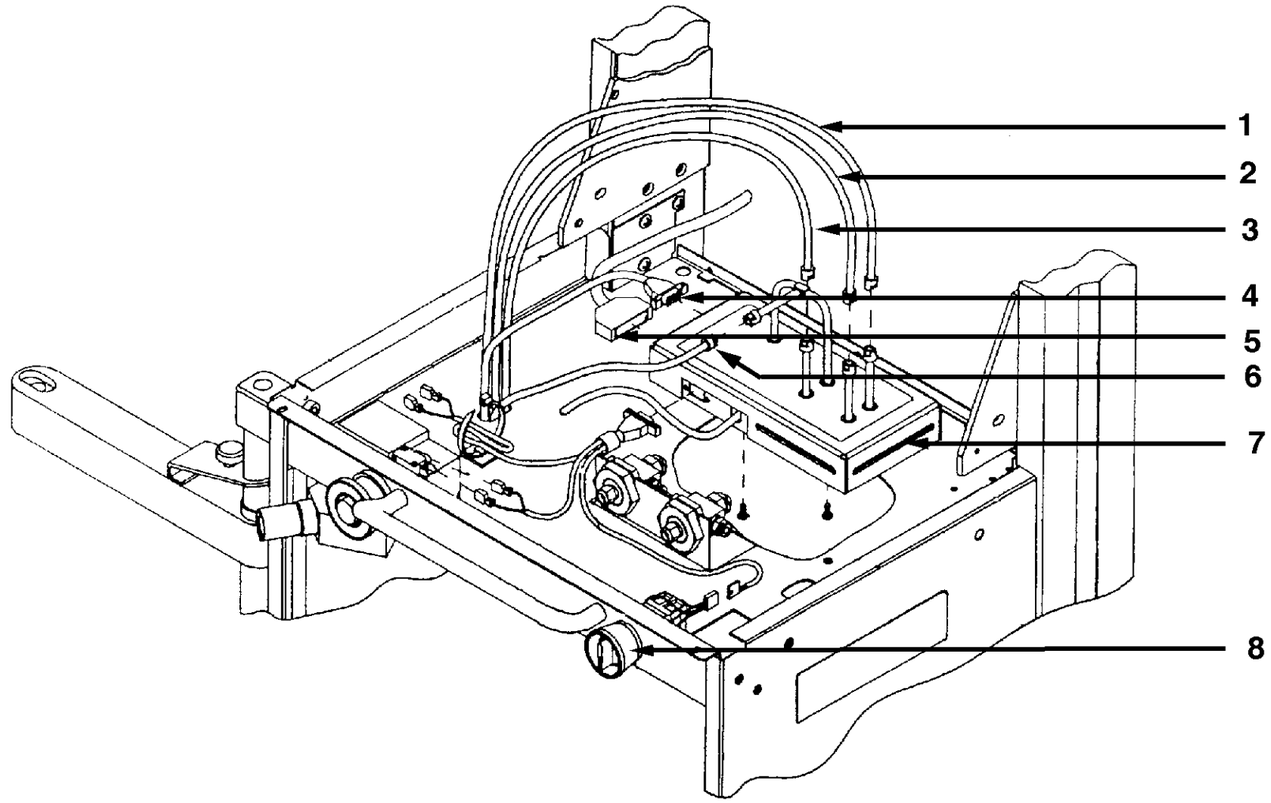



**Figure 8-3**
Patient interface cable - Machine side




1. Coded yellow Expiratory transducer high
2. Coded blue Expiratory transducer low
3. Coded black Inspiratory transducer low
4. Patient interface cable connect
5. SIB/7900 Vent interface cable
6. Coded natural Inspiratory transducer high and airway pressure monitor connect
7. SIB assembly housing
8. System ON/Standby switch

**Figure 8-4**
SIB interface, hose and cable routing

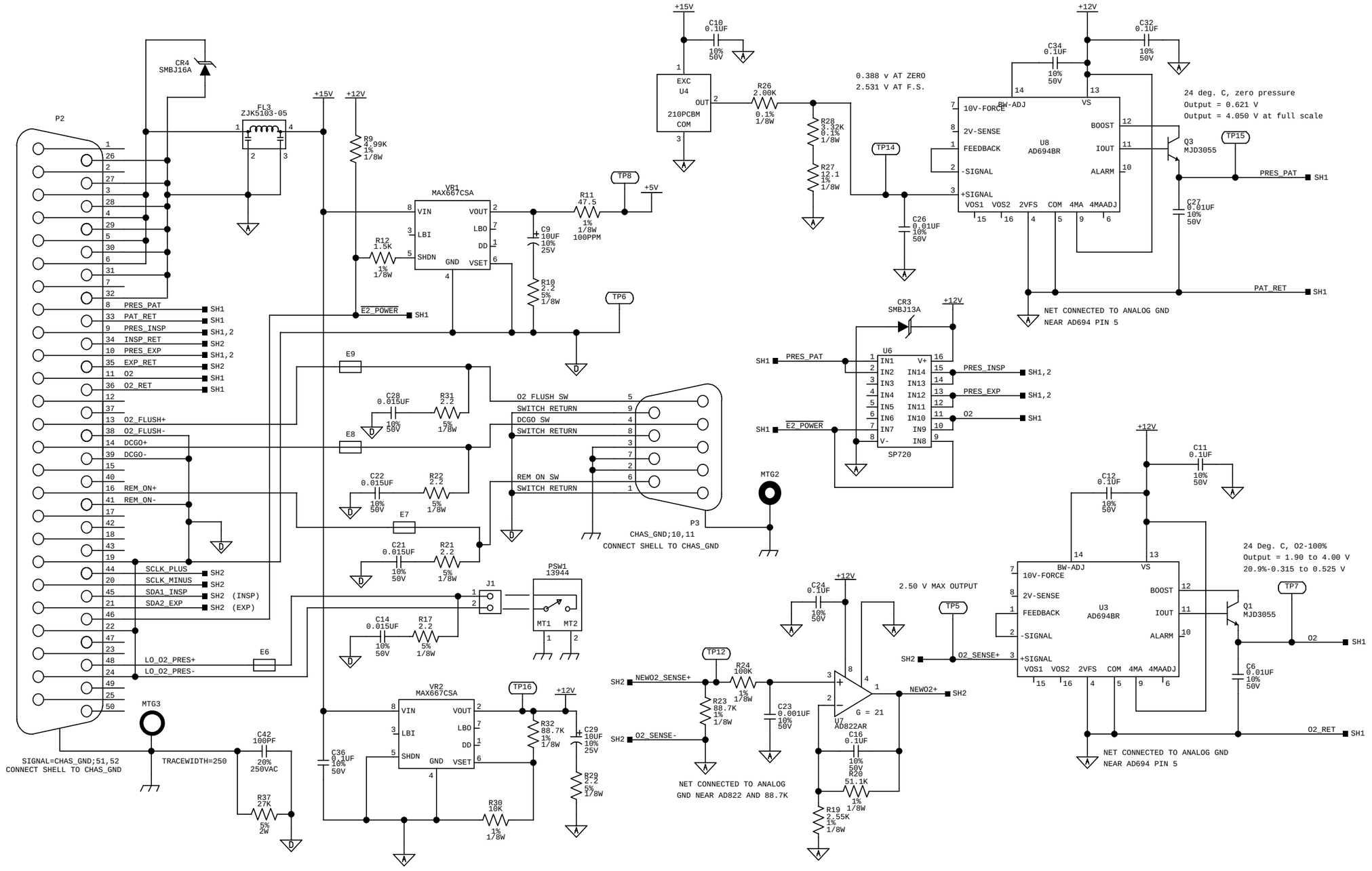



**Figure 8-5**
7900 SIB schematic diagram, page 1 of 2

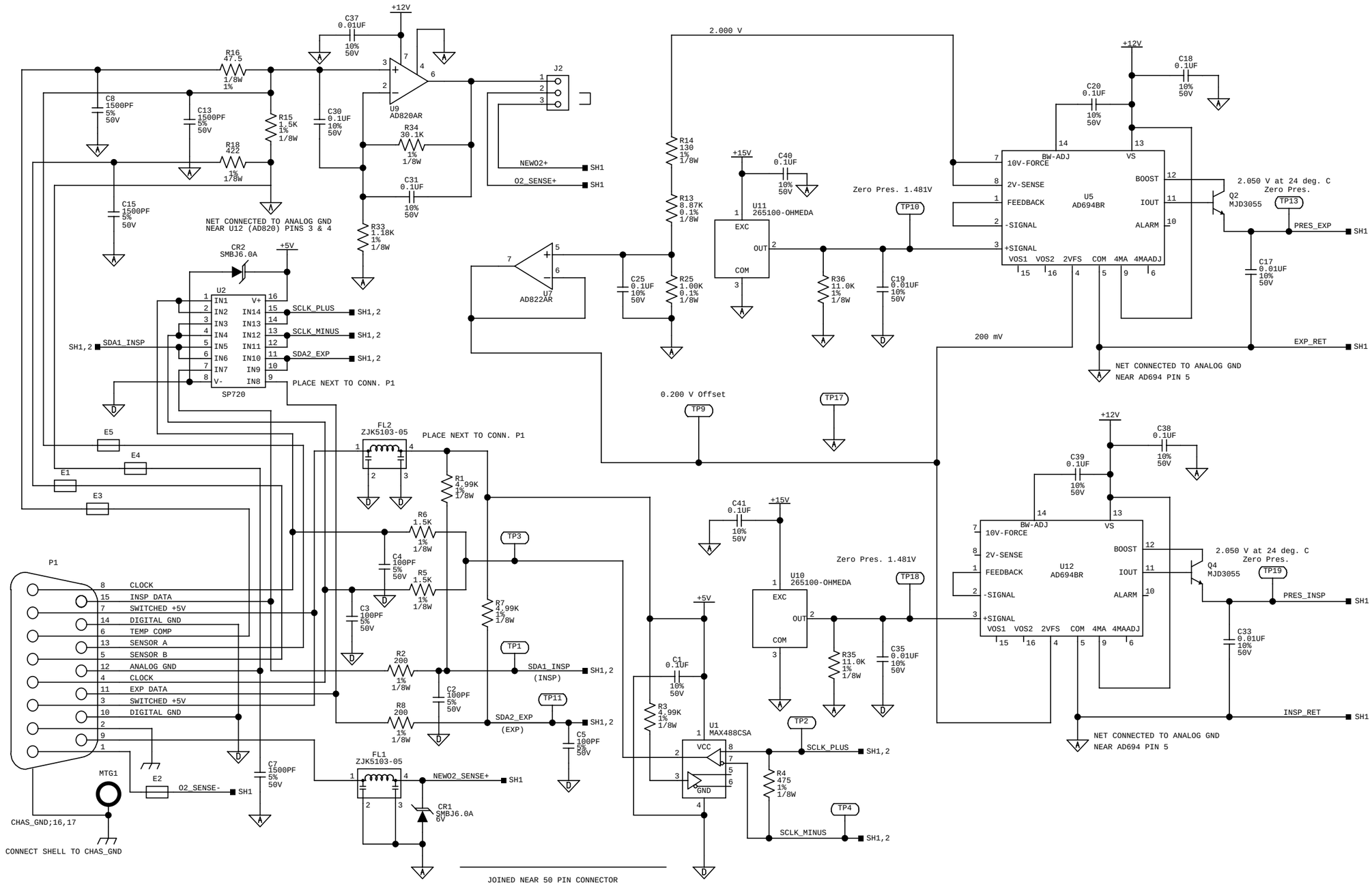



**Figure 8-6**
7900 SIB schematic diagram, page 2 of 2

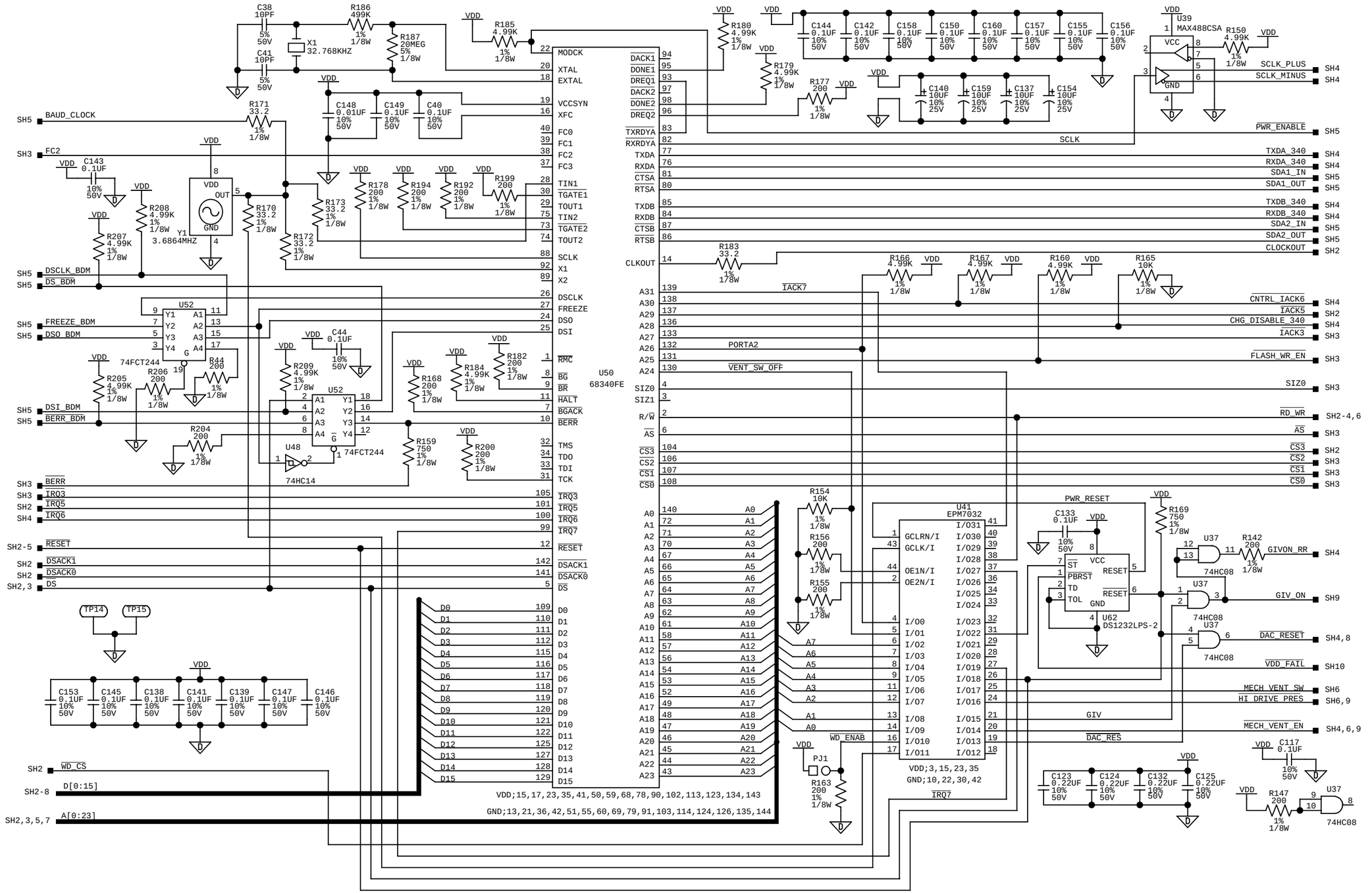



**Figure 8-7**
Microcontroller board schematic diagram, page 1 of 10

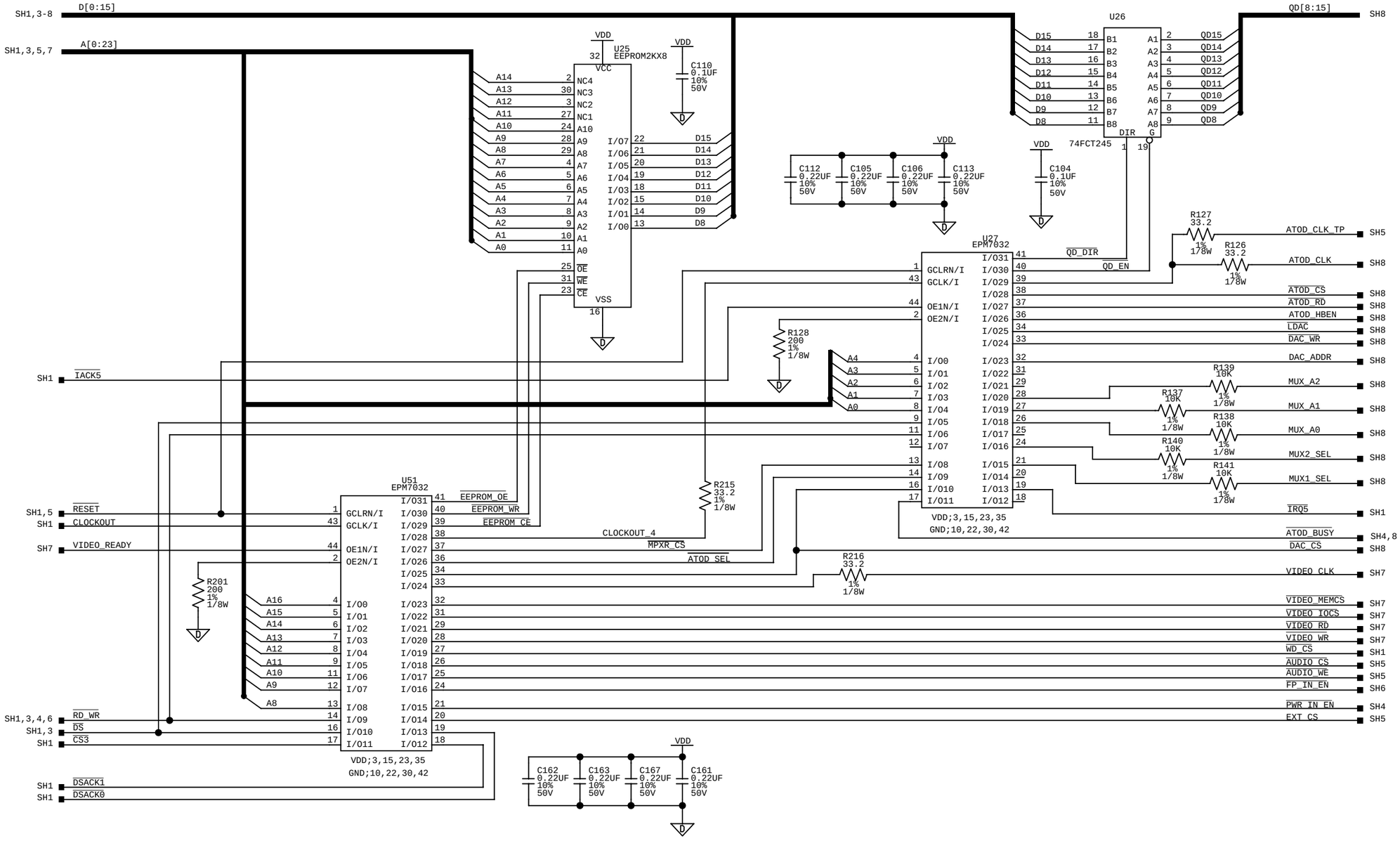



**Figure 8-8**
Microcontroller board schematic diagram, page 2 of 10

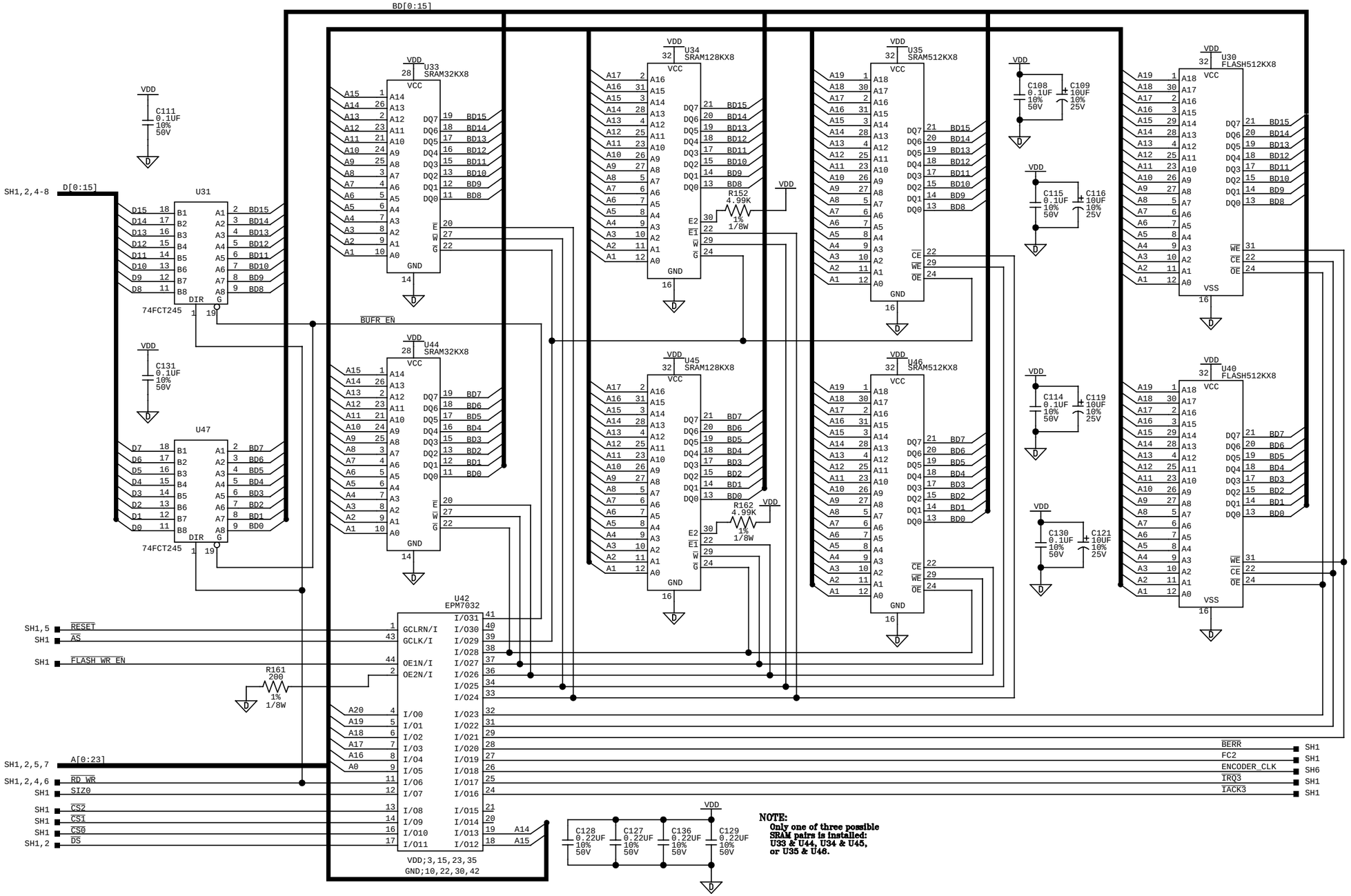



**Figure 8-9**
Microcontroller board schematic diagram, page 3 of 10

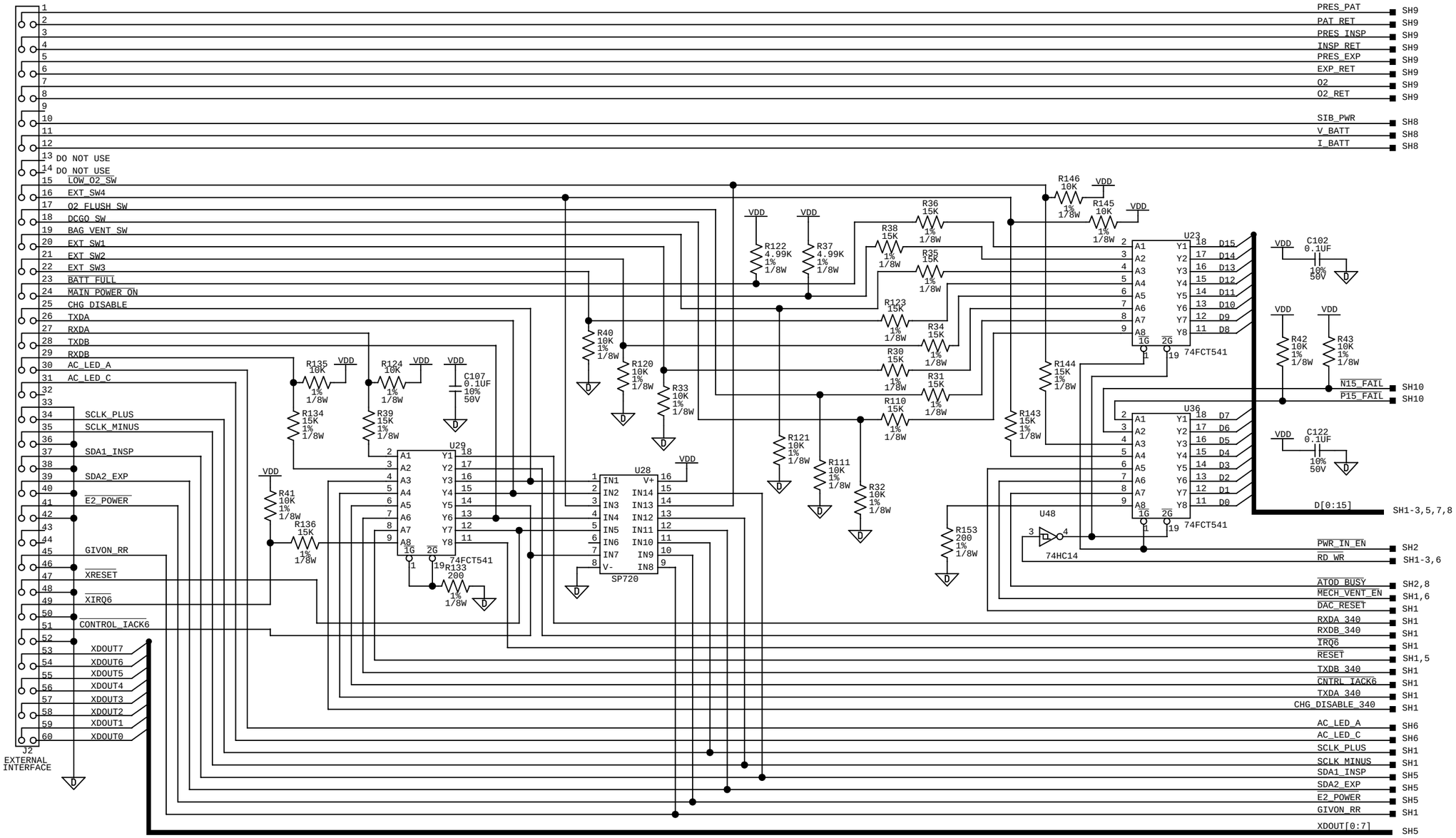



**Figure 8-10**
Microcontroller board schematic diagram, page 4 of 10

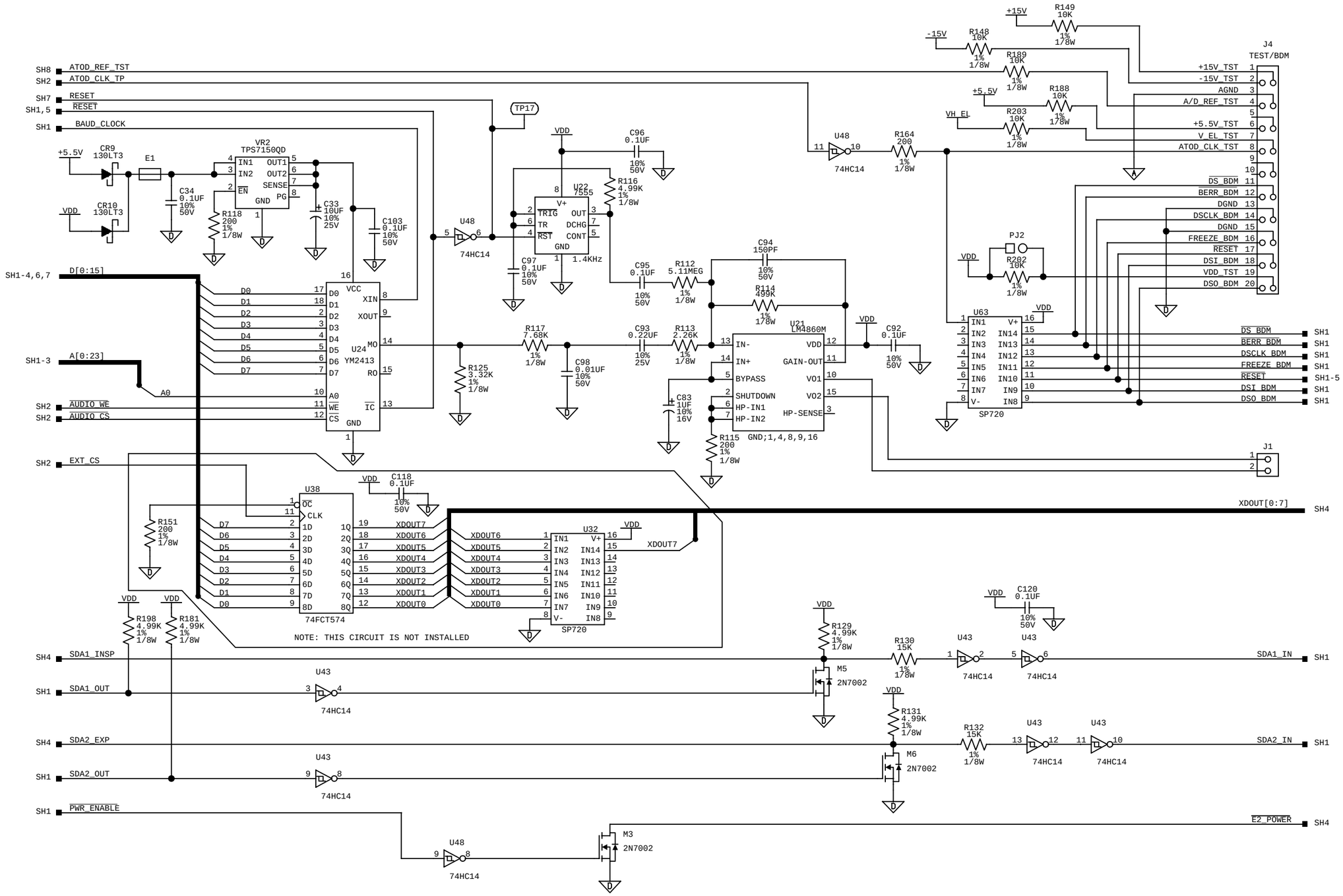



**Figure 8-11**
Microcontroller board schematic diagram, page 5 of 10

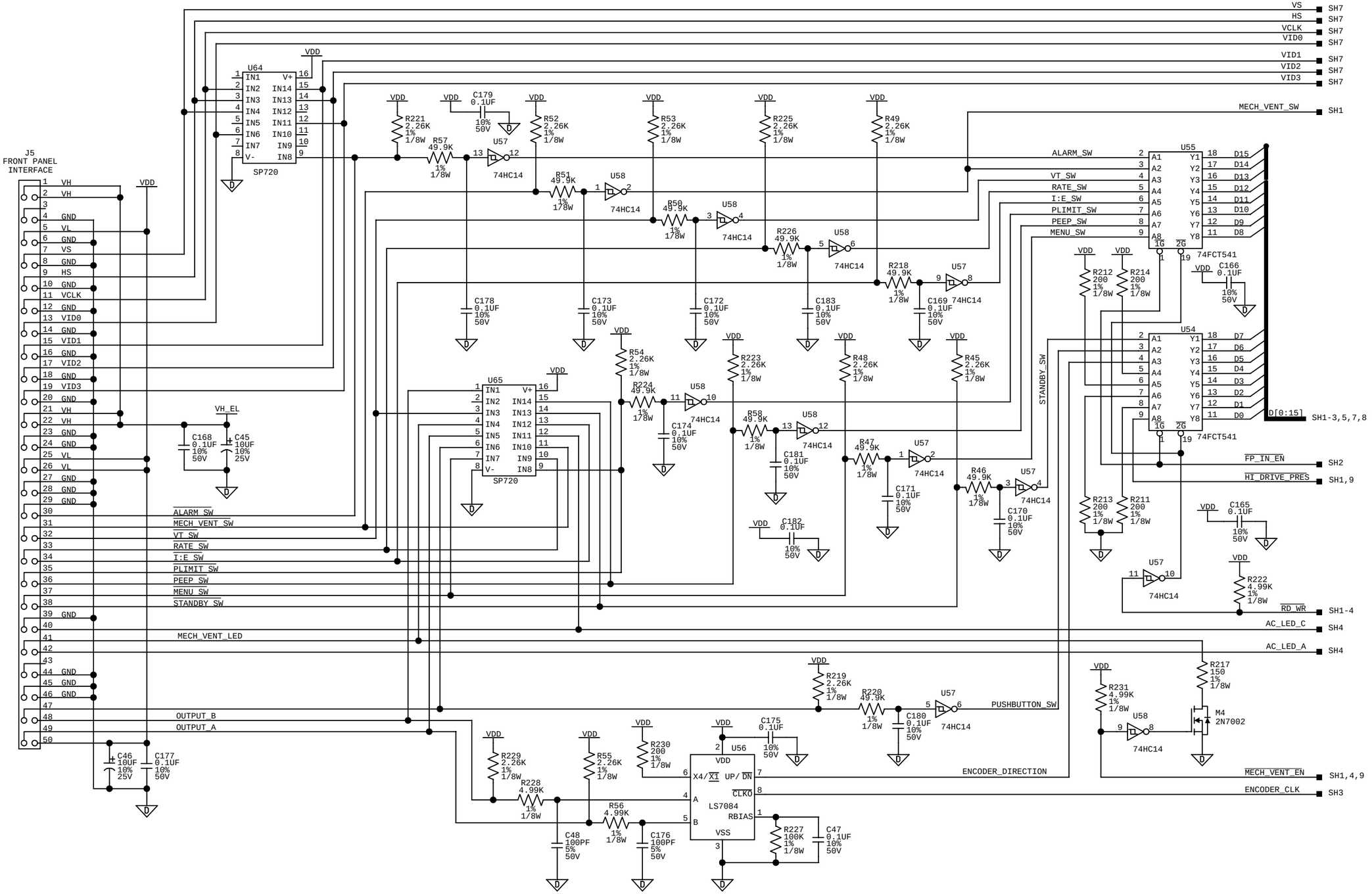



**Figure 8-12**
Microcontroller board schematic diagram, page 6 of 10

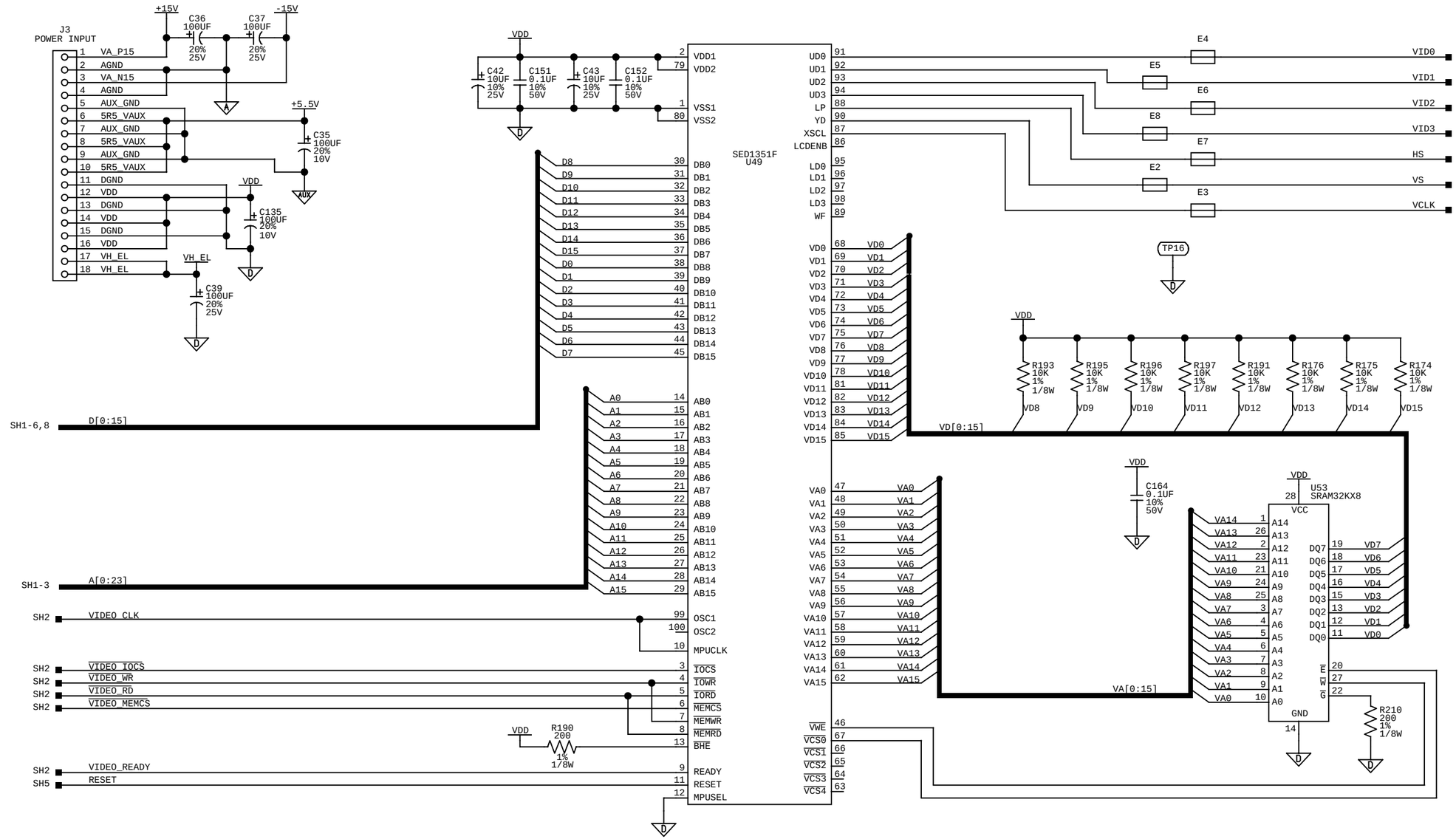



**Figure 8-13**
Microcontroller board schematic diagram, page 7 of 10

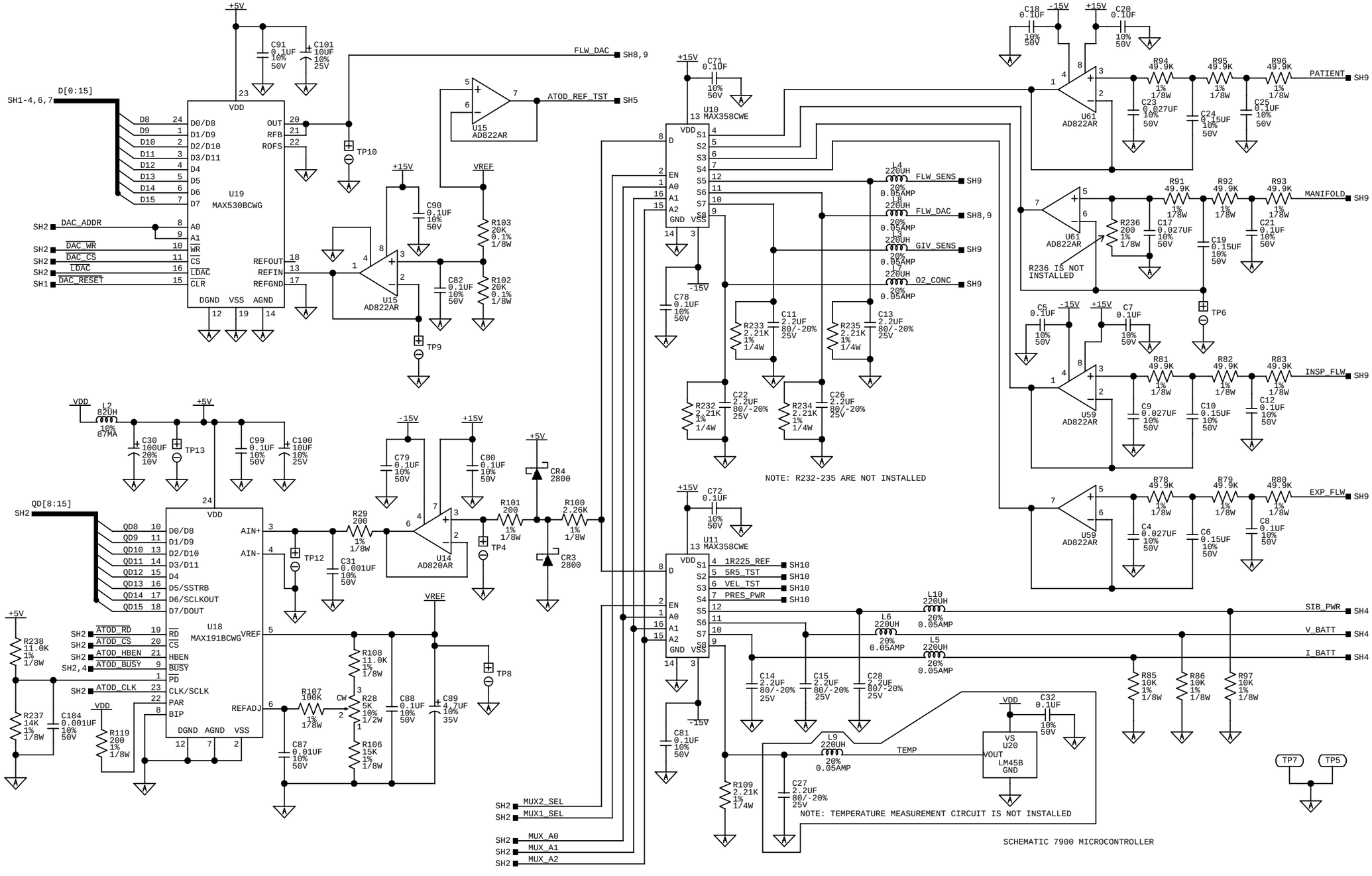



**Figure 8-14**
Microcontroller board schematic diagram, page 8 of 10

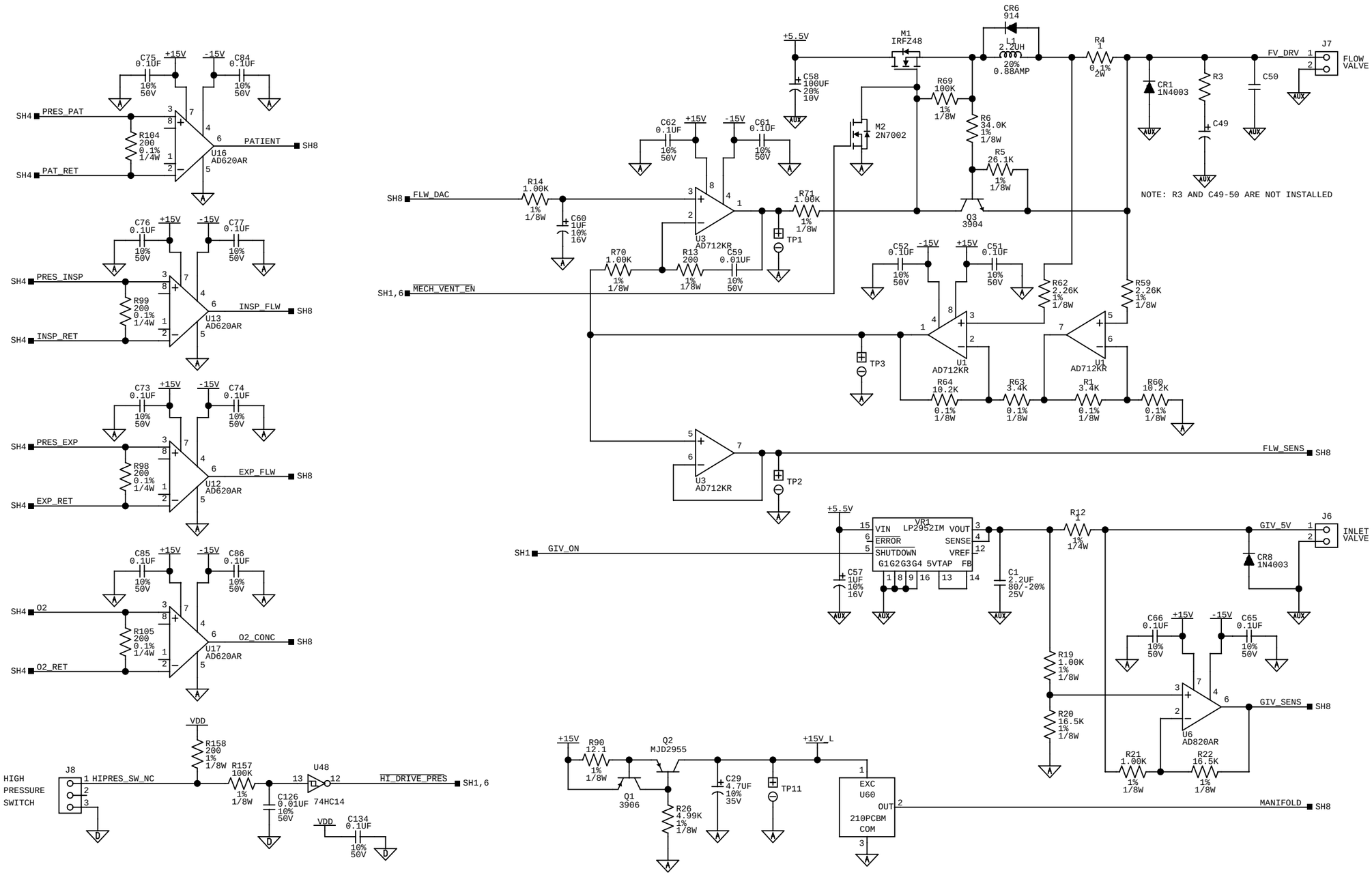



**Figure 8-15**
Microcontroller board schematic diagram, page 9 of 10

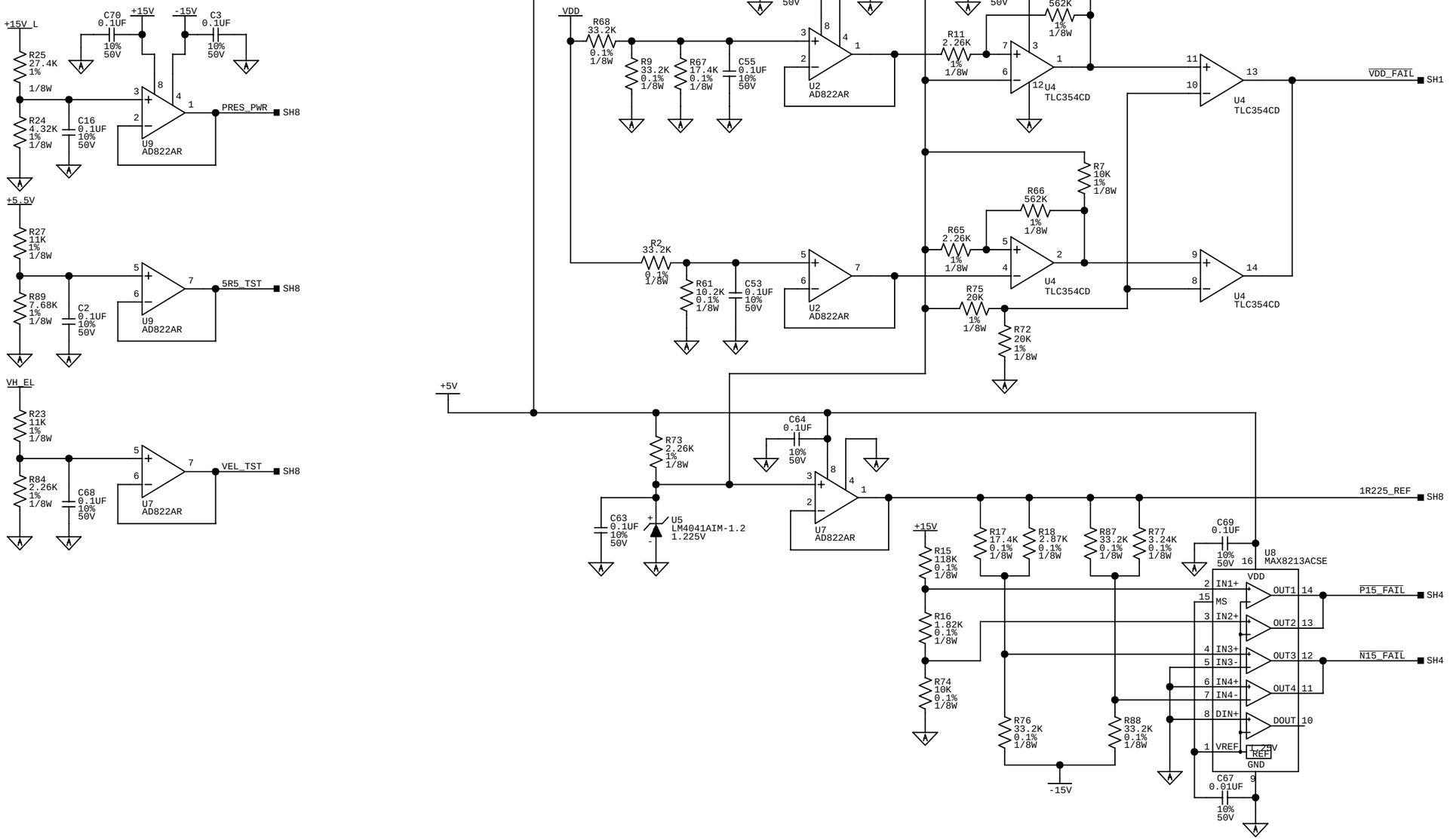



**Figure 8-16**
Microcontroller board schematic diagram, page 10 of 10

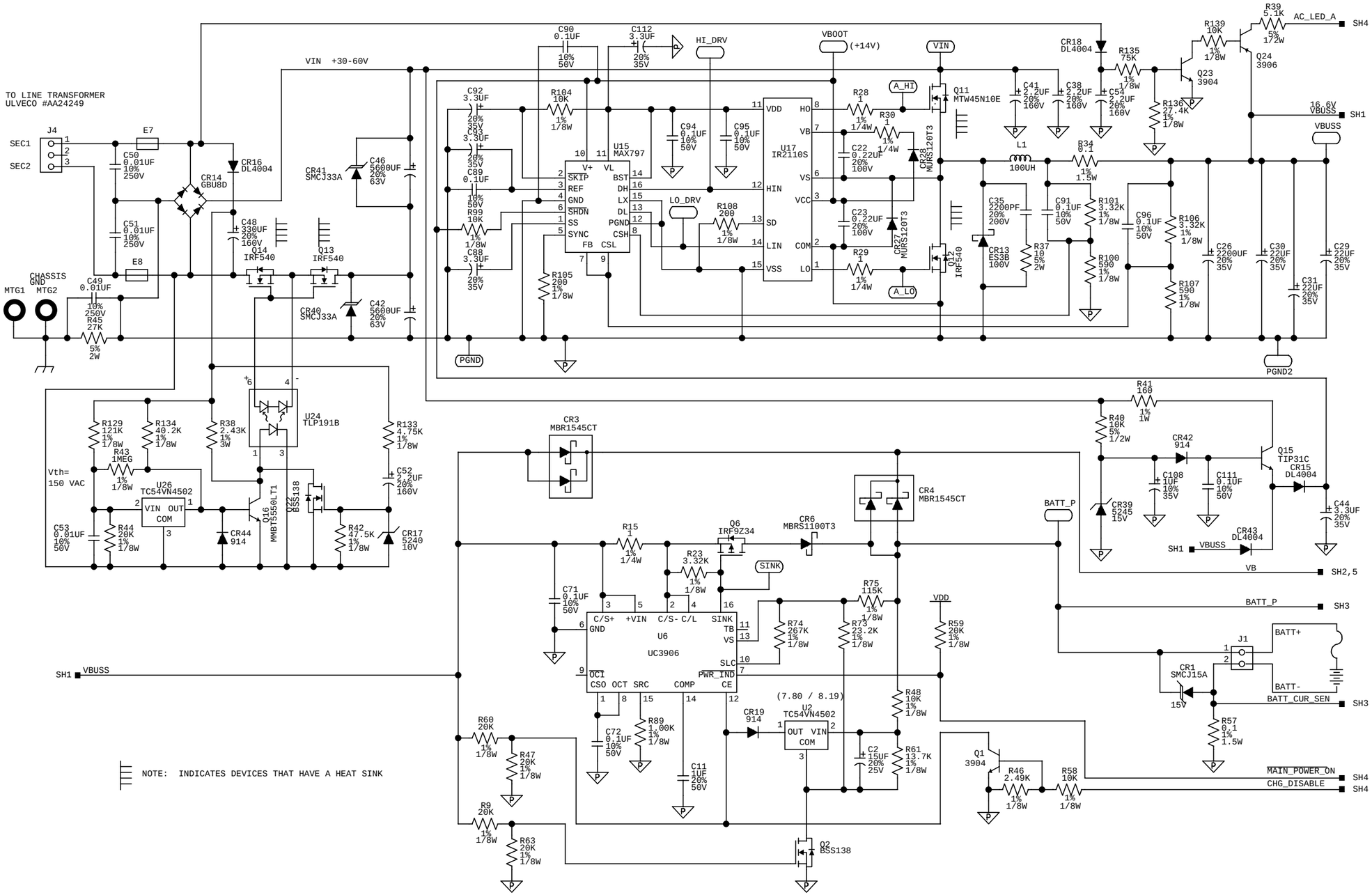



**Figure 8-17**
Power supply board schematic diagram, page 1 of 5

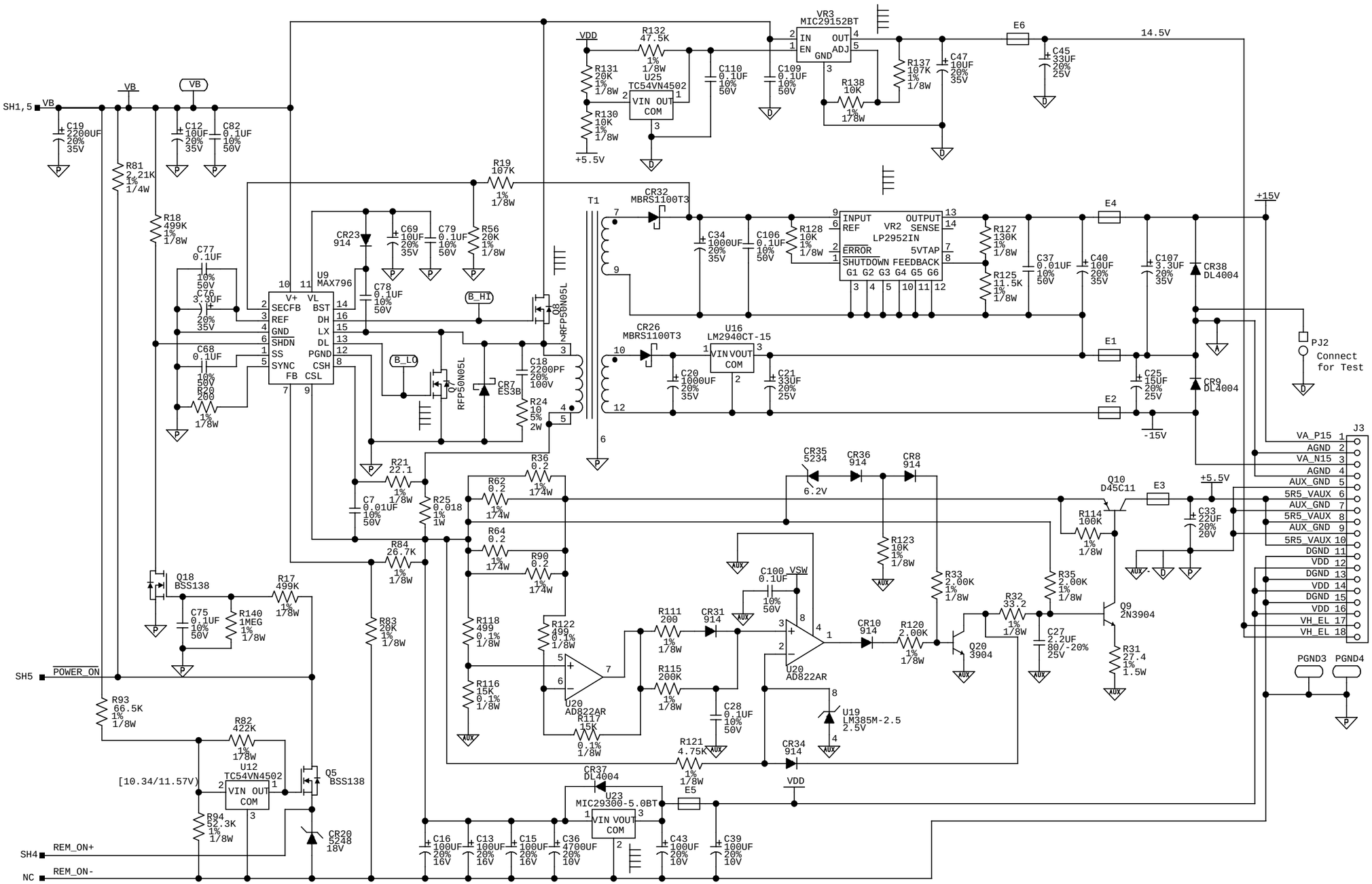



**Figure 8-18**
Power supply board schematic diagram, page 2 of 5

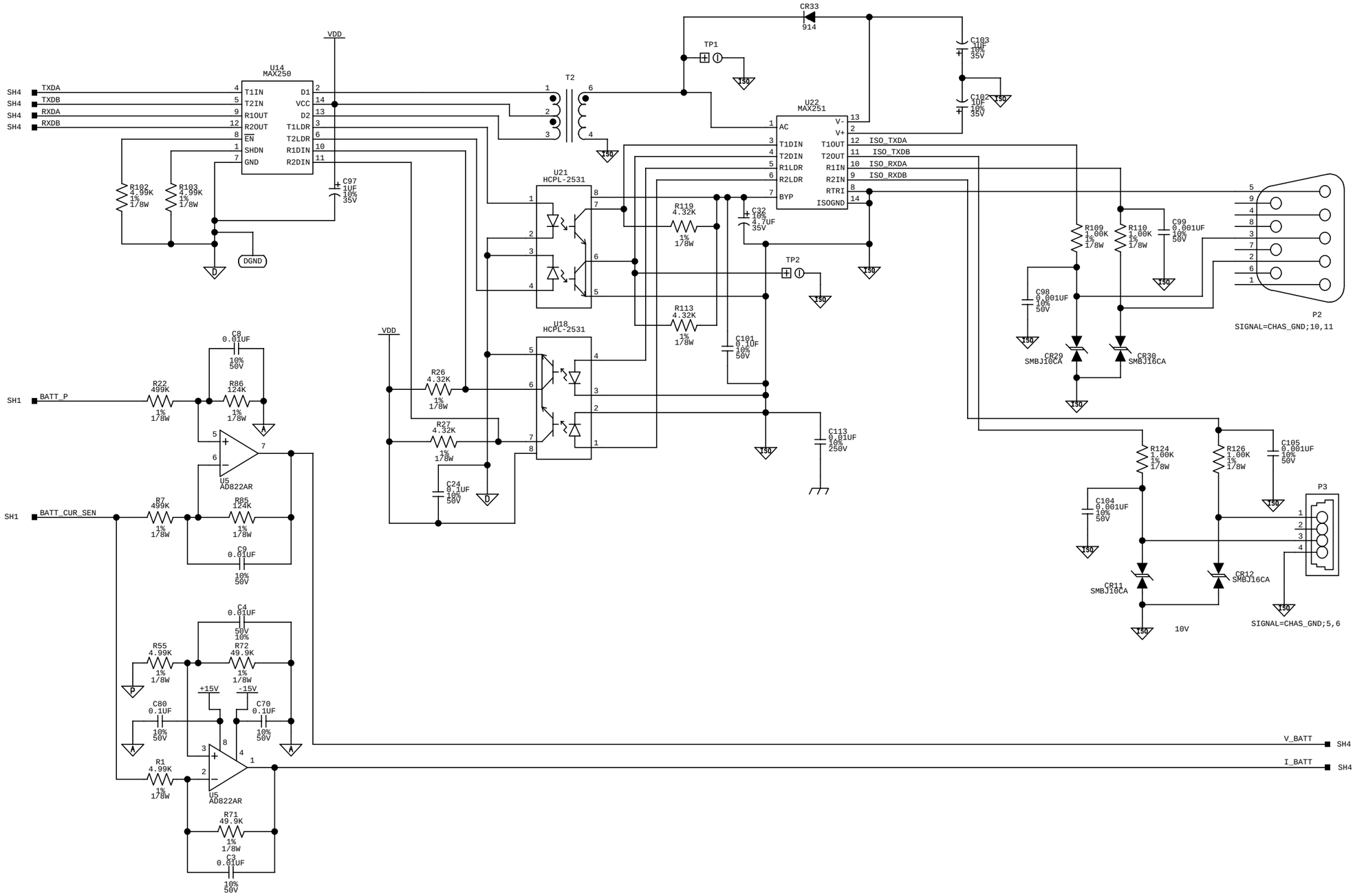



**Figure 8-19**
Power supply board schematic diagram, page 3 of 5

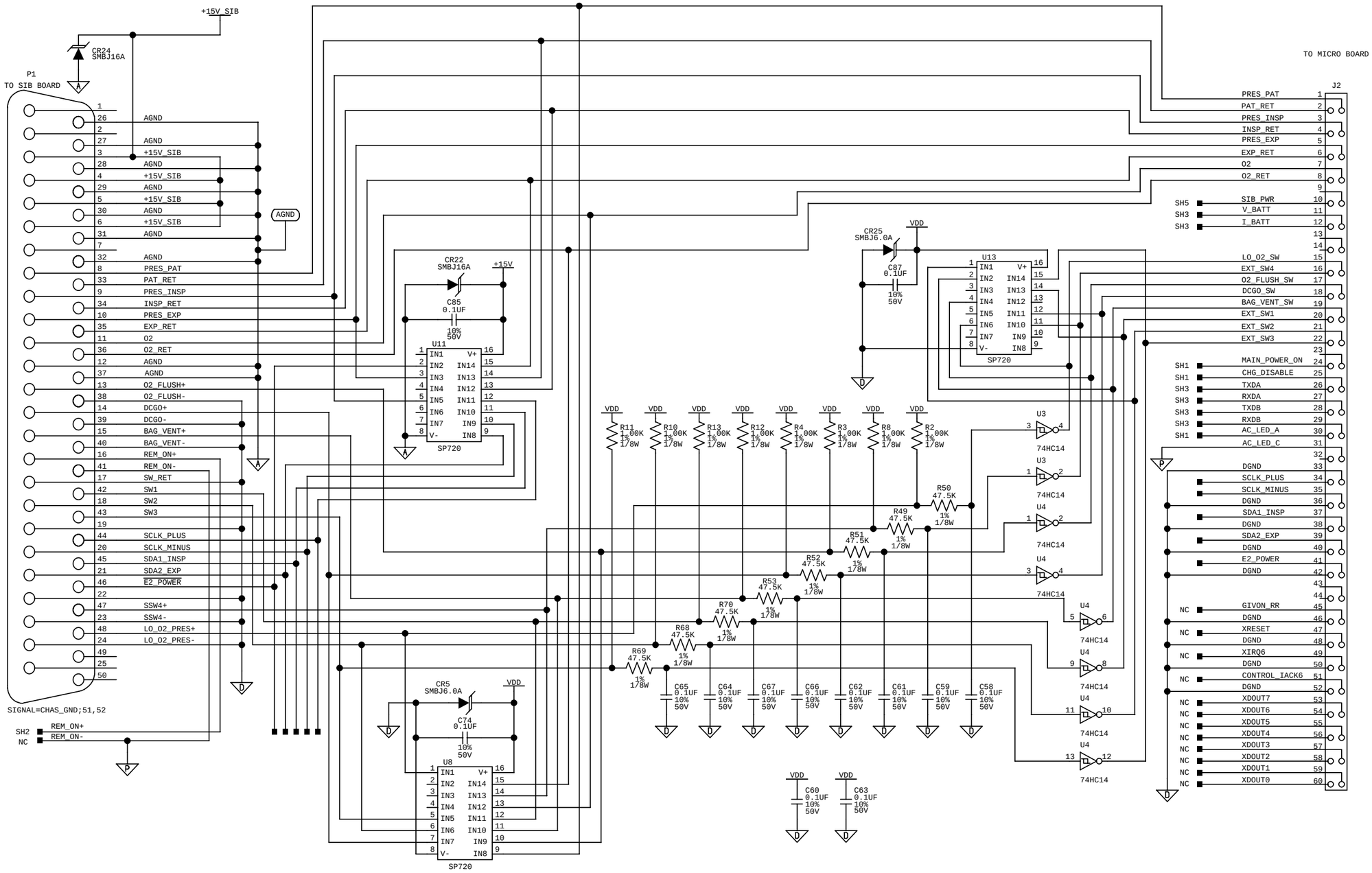



**Figure 8-20**
Power supply board schematic diagram, page 4 of 5

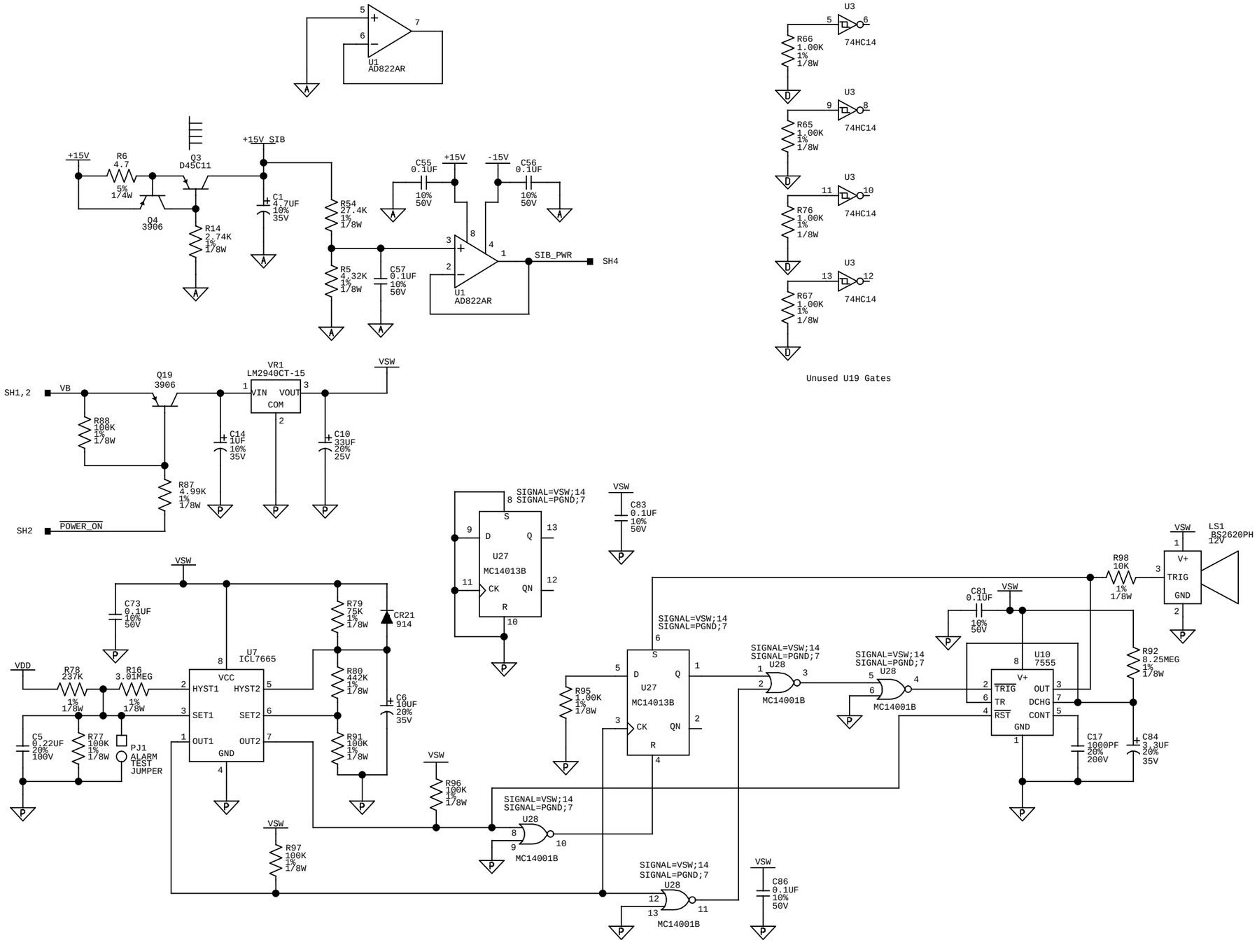



**Figure 8-21**
Power supply board schematic diagram, page 5 of 5

## 7900 Accessory and Bellows Mounting:

### Kit Accy Common Parts 1503-8001-000

Mounting plate assembly ABA
Bellows assembly autoclaveable
Diaphragm assembly
Gasket, manifold
O-rings
Hoses GMS Vent interface (4)
Flow transducer
Adapter $O_2$ sensor
$O_2$ sensor
Label

### Kit Mtg For ABA to GMS 1503-8002-000

Loctite
Support SA bellows
Screws 3/8 - 24 x 3/4 (2)
Label ABA to GMS
Knob with stud
Truarc ring
Shelf ABA to GMS mtg
Manifold assembly ABA to GMS
Support guide ABA to GMS
Screw M5 x 12
Instal inst.

### Arm Assy Vent/Bellows Mtg 1503-8003-000

Groove pin
Washers flat (2)
Screw, 10 x 24 x 1/2 (3)
Lubriplate
Filter, disposable w/tube
Washer 6.4 mm ID x 14.3 mm OD
Screw M6
Pawl w/o pin pivot
Plate vent and bellows mtg
Flange mtg post
Arm, vent mtg bracket
Thumb screw
Label/Instal inst.

### Kit Exh Vlv Manifold 1503-8004-000

Diaphragm assembly (2)
Manifold assembly
Gasket, manifold
O-rings (2)
Instruct pkg & parts

## O&M Manuals:

### Revision 1.5

| | |
|---|---|
| Domestic | 1503-0140-000 |
| Deutsch | 1503-0141-000 |
| Francais | 1503-0142-000 |
| Espanol | 1503-0143-000 |
| Italiano | 1503-0144-000 |
| Japanese | 1503-0145-000 |
| Svenska | 1503-0152-000 |

### Revision 2.x

| | |
|---|---|
| Domestic | 1503-0177-000 |
| Deutsch | 1503-0178-000 |
| Francais | 1503-0179-000 |
| Espanol | 1503-0180-000 |
| Italiano | 1503-0181-000 |
| Japanese | 1503-0182-000 |
| Swedish | 1503-0183-000 |
| Danish | 1503-0184-000 |
| Polish | 1503-0185-000 |
| Hungarian | 1503-0186-000 |
| Czech | 1503-0187-000 |

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